UNIT TERMINAL OBJECTIVE

4-1 At the completion of this unit, the Paramedic student will be able to integrate the principles of kinematics to enhance the patient assessment and predict the likelihood of injuries based on the patient's mechanism of injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the Paramedic student will be able to:

4-1.1 List and describe the components of a comprehensive trauma system. (C-1)
4-1.2 Describe the role of and differences between levels of trauma centers. (C-3)
4-1.3 Describe the criteria for transport to a trauma center. (C-1)
4-1.4 Describe the criteria and procedure for air medical transport. (C-1)
4-1.5 Define energy and force as they relate to trauma. (C-1)
4-1.6 Define laws of motion and energy and understand the role that increased speed has on injuries. (C-1)
4-1.7 Describe each type of impact and its effect on unrestrained victims (e.g., "down and under," "up and over," compression, deceleration). (C-1)
4-1.8 Describe the pathophysiology of the head, spine, thorax, and abdomen that result from the above forces. (C-1)
4-1.9 List specific injuries and their causes as related to interior and exterior vehicle damage. (C-1)
4-1.10 Describe the kinematics of penetrating injuries. (C-1)
4-1.11 List the motion and energy considerations of mechanisms other than motor vehicle crashes. (C-1)
4-1.12 Define the role of kinematics as an additional tool for patient assessment. (C-1)

AFFECTIVE OBJECTIVES

None identified for this unit.

PSYCHOMOTOR OBJECTIVES

None identified for this unit.

DECLARATIVE

I. Introduction
- A. Epidemiology of trauma
  1. A leading cause of death for people 1- 44 years of age
  2. 140,000 unexpected deaths per year
  3. Automobile related deaths are > 40,000
  4. Penetrating trauma may exceed blunt in near future
  5. Pre-incident, incident, post-incident phase
- B. History
  1. Complete and accurate history of incident will identify possibility for 95% of the injuries present
  2. Incident site
     a. Indications of severity of injury
  3. Major factors of tissue injury
  4. Amount of energy exchanged
  5. Anatomical structures potentially involved

II. Trauma systems
- A. Components
  1. Injury prevention
  2. Prehospital care
     a. Treatment
     b. Transportation
     c. Trauma triage guidelines
  3. Emergency department care
  4. Interfacility transportation - if necessary
  5. Definitive care
  6. Trauma critical care
  7. Rehabilitation
  8. Data collection/ trauma registry
- B. Trauma centers
  1. Levels
  2. Qualifications
     a. Essential
     b. Desired
  3. Role
- C. Transport considerations
  1. Level of receiving facility
  2. Mode of transport
     a. Ground transport
        (1) If appropriate facility can be reached within reasonable time
        (2) To a more accessible landing zone for air medical transport
     b. Air medical transport
        (1) Indications

(2) Contraindications
(3) Procedure

III. Energy
A. Physical laws
1. Newton's first law of motion
a. A body at rest or a body in motion will remain in that state until acted upon by an outside force
b. In a vehicle traveling at 50 mph, the occupant is also traveling at 50 mph
c. When the car stops, the occupant continues to travel at 50 mph until some force acts on the occupant
2. Conservation of energy
a. Energy cannot be created nor destroyed
b. It can be changed in form
c. Energy can be absorbed producing deformation of substance
3. Kinetic energy (KE)
a. KE = ½ the mass of the object multiplied by the velocity (speed) of the object squared (Mass/2 x V^2)
b. Velocity (V) influences KE more than mass
c. Greater speed means more energy generated
4. Force
a. Force = Mass x Acceleration
b. Force = Mass x Deceleration
c. Mass x Acceleration = Force = Mass x Deceleration
d. Simply put, to accelerate a bullet from a the muzzle of a weapon requires the force from the explosion of the gunpowder; once the bullet is set in motion by this explosion, an equal amount of tissue destruction must occur inside the body to stop it as was used to start it
5. Energy law summary
a. Motion is created by force (energy exchange)
b. Force (energy exchange) must stop this motion
c. If such energy exchange occurs inside the body tissue damage is produced
B. Energy exchange
1. Cavitation
a. Energy exchange produces particle motion
b. Temporary cavity
(1) Short lived
(2) Produced by stretching
(3) Dependent on the elasticity of the object involved
(4) Produces particle compression at the limits of the cavity
c. Permanent cavity
(1) Visible when the energy exchange has been completed
(2) Produced by compression and destruction
2. Interaction between two bodies
a. At least one must be in motion

b. Both can be in motion
3. Dependent on number of particles involved in the interface of the interaction
a. Density of the interacting bodies
(1) Air density (few particles)
(a) Lung
(b) Intestinal tract
(2) Water density (more particles)
(a) Vascular system
(b) Liver
(c) Spleen
(d) Muscle
(3) Solid density (thick particles)
(a) Bone
(b) Asphalt
(c) Steel
b. Area on interaction
(1) Shape of object
(2) Position of object
(3) Fragmentation of object

C. Types on trauma based on ingress
1. Blunt
a. Tissue not penetrated
b. Cavitation away from site of impact
c. Cavitation in direction of impact
2. Penetrating
a. Tissue penetrated
b. Cavitation at 90^{o} to bullet pathway
(1) Tissue inline to penetration is crushed

IV. Blunt trauma
A. Vehicle collisions
1. Frontal
2. Lateral
3. Rear
4. Rotational
5. Roll over
B. Occupant collisions
1. Frontal impacts
a. Down and under
(1) Feet impact floor pan
(2) Knees impact dash
(a) Tibia impact
i) Knee dislocation
ii) Popliteal artery disruption
iii) Knee support disruption

(b) Femur impact
i) Femur fracture
ii) Acetabular posterior fracture dislocation
(3) Torso rotates
(a) Steering column
(b) Dash
(c) Windshield
b. Up and over
(1) Head impact
(a) Windshield
(b) Roof
(c) Mirror
(2) Chest impact
(a) Steering column
(b) Dash
(3) Abdominal impact
(a) Steering column
(b) Dash
2. Lateral impacts
a. Vehicle moves into and impacts body
(1) Chest
(2) Pelvis
(3) Body moves laterally
(a) Neck
i) Rotates
ii) Lateral flexion
iii) Combination
3. Rear impacts
a. Vehicle seat pushes body
(1) All body parts in contact with seat move
(2) Body parts not in contact dragged along with torso
b. Secondary impact if vehicle hits another object
(1) Similar to frontal impact
4. Rotational impacts
a. Part of vehicle stops; the rest remains in motion
b. Combination of frontal and lateral impacts
5. Roll over
a. Difficult to predict the body impacts

C. Organ collisions
1. Two types of injury from blunt trauma
a. Compression
b. Change in velocity
(1) Acceleration
(a) Shear
(b) Avulsion

(2) Deceleration
(a) Shear
(b) Avulsion

2. Organ collisions with different vehicular collisions
a. Frontal impacts
(1) Head
(a) Compression
i) Skull fractures
ii) Cerebral contusion
(b) Deceleration
i) Opposite end separation
ii) Hemorrhage
iii) Brain stem stretch
(2) Neck
(a) Compression
i) Vertebral body
a) Compression fracture
b) Hyperextension injury
- Posterior element compression
- Anterior body separation
c) Hyperflexion injury
- Anterior body compression
- Posterior element separation
(b) Shear
i) Not significant
(3) Thorax
(a) Chest wall
i) Compression
a) Fracture rib(s) - producing single rib fractures, flail chest, and/or pneumothorax
ii) Shear
a) Fracture thoracic spine
(b) Heart
i) Compression
a) Contusion
b) Rupture
ii) Shear
a) Not significant
(c) Aorta
i) Compression
a) Not significant
ii) Shear
a) Junction arch and descending portions
b) Aortic origin at the aortic valve

c) A t the diaphragm
(d) Lung
i) Compression
a) Pneumothorax
b) Rib fracture and penetration
ii) Shear
a) Not significant
(4) Abdomen
(a) Abdominal cavity
i) Diaphragm
a) Compression tears
b) Shear - not significant
ii) Abdominal wall
a) Compression tears
b) Shear - not significant
(b) Liver
i) Compression
a) Burst type injuries
ii) Shear
a) Tears from Ligamentum Teres
b) Avulsion of liver from inferior vena cava at the hepatic veins
(c) Spleen
i) Compression
a) Burst
ii) Shear
a) Avulsion of pedicle
(d) Gastrointestines
i) Compression
a) Rupture
ii) Shear
a) Avulsion of mesenteric vessels from aorta or vena cava
b) Tears along mesenteric vessels
c) Avulsion of vessels from intestine
(e) Gall bladder
i) Compression
a) Rupture
ii) Shear
a) Avulsion from liver
b) Avulsion of cystic duct
b. Lateral impacts
(1) Head
(a) Compression
i) Similar to frontal except lateral head and on the

side of the impact to the vehicle

(b) Shear
- i) Shear of brain and vessels opposite side of the impact

(2) Cervical spine
- (a) Compression
  - i) Minimal unless head hits the top of the passenger compartment or the support for the windows
- (b) Shear
  - i) Two fold mechanism
  - ii) Rotation
    - a) Center of gravity of the head is anterior to the pivot point of the head and the spine at the odontoid process; as lateral impact occurs the torso and then the C-spine is pushed under the head; the head rotates in relative position to the body, toward the impact
    - b) The center of gravity of the head is also cephalad to the point of support at the cervical spine; as the lateral forces push the torso away from the point of impact the motion of the head produces lateral flexion of the head
    - c) The combination of these two forces is lateral flexion of the neck opening the facets opposite the side of impact and rotation of the vertebral bodies in relation to each other; the result is jumped facets and if the force is great enough significant torsion of the spinal cord

(3) Thorax
- (a) Compression
  - i) Impact of the door into the thorax
    - a) Lateral ribs - fractures and flail chest
    - b) Lung - pneumothorax
    - c) Spleen or liver - lacerations and hemorrhage
- (b) Shear
  - i) Lateral motion of the thoracic spine as the torso is pushed away from the impact
  - ii) Thoracic aorta moves with the spine
  - iii) Arch and heart do not move until traction on the arch

iv) Shear forces tear the aorta at the junction of the movable arch and the descending aorta that is attached to the thoracic spine

(4) Abdomen
- (a) Compression
  - i) Liver or spleen depending of the side of the impact
  - ii) Kidneys depending of the side of the impact
  - iii) Diaphragm similar to frontal impact
- (b) Shear
  - i) Abdominal aorta moves with the lumbar spine
    - a) Shear of the renal vessels
    - b) Shear of the splenic vessels

(5) Pelvis
- (a) Compression
  - i) Impact on the femur
    - a) Femoral head driven through the acetabulum
    - b) Fracture of the ileum
    - c) Sacro-iliac joint fracture
    - d) Fracture of the other bones of the pelvis

(6) Extremities
- (a) Compression
  - i) Clavicle compressed between the humerus and the sternum
  - ii) Lateral compression of the humerus

c. Rear impact

(1) Physics
- (a) Energy (velocity) imparted to the rear
  - i) Moves all attached parts of the vehicle
  - ii) Occupants in direct contact with vehicle move also
  - iii) Parts of the occupants not in direct contact do not move until pulled along
    - a) Newton's first law of motion
    - b) Unrestricted body parts will be separated or at least stretched by this differential velocity
  - iv) The force of the energy exchange depends on the differential energy of the two vehicles and the exchange of energy between the two

(2) Head
- (a) Compression
  - i) Into structures behind the seat
  - ii) Energy of compression depends on the force of

the change of energy between the vehicle and the impact into the head

(b) Shear
i) Separation of the brain and skull in front

(3) Neck
(a) Compression
i) Unrestrained occupant into the top of the passenger compartment or into the rear seat
(b) Shear
i) Head restraint not in the correct position to move the head forward with the motion of the vehicle
ii) Neck hyperextended over the malpositioned head restraint; usually only ligamentous and tendon stretch and no fractures

(4) Torso
(a) As most of the torso is in contact with the seat and springs of the seat only minimal differential energy is exchanged onto the body parts
(b) Unless there is rebound when the vehicle hits another vehicle there is little injury to the torso in the rear impact collision

(5) Extremities
(a) The extremities move with the torso and receive very little differential exchange with rear impacts

d. Rotational impacts
(1) In the pure rotational impact, one part of the vehicle hits an immovable object, while the rest continues in motion (Newton's first law of motion)
(2) As the one part stops and the rest of the vehicle continues to move the vehicle moves around the fixed point
(3) The motion to the occupant is a combination of two motions
(a) Frontal and lateral
(b) Rear and lateral
(4) The injuries are combinations of the two motions with emphasis on the initial impact motion

e. Roll over
(1) In a roll over the pattern of injuries is very difficult as the unrestrained occupant can hit all parts of the vehicle

f. Ejection
(1) If the force is such and the occupant is unrestrained then ejection is possible
(2) The major injuries occur inside of the vehicle and on the way out rather than afterward on impact the ground or some other object
(3) Since the major part of the injuries occur on the way out, the Paramedic can better predict the injuries by thinking of the first

part of the collision rather than the latter portion

D. Restraints
   1. Restraints are systems for absorbing the energy of the impact before the occupant hits something hard and limiting the distance the body has to travel thus helping to decrease velocity (speed)
   2. Belt restraint
      a. Contrary to popular belief the belt restraints work on lateral impacts as we as in frontal impacts (they are not quite as effective in lateral impacts because the hard parts of the passenger compartment is closer on the sides than in the front therefore the belt systems do not have as much distance to be effective)
      b. The benefit of the belt restraint can be seen on any Sunday at the automobile race track
      c. Lap belts
         (1) Benefits
            (a) Hold the lower torso in close approximation to the seat and away from the dash or steering column
            (b) Prevent
               i) Forward motion of the lower torso in frontal collisions
               ii) Moves the torso with the vehicle and away from the impact in lateral impact collisions
               iii) Prevents multiple impacts in rollover collisions
               iv) Prevents ejection
            (c) Attached to the floor behind the occupant at a 45^{o} angle to the floor
            (d) Prevent forward motion of the pelvis by supporting the anterior part of the pelvis
            (e) No impingement on the soft intra-abdominal contents
         (2) Limitations
            (a) Upper torso is not supported
            (b) If positioned above the anterior iliac spine, the belt stops the forward motion of the body against the lumbar spine with the intra-abdominal organs crushed between the belt and the spine
            (c) High position can fracture or dislocate the lumbar spine
            (d) Increased intra-abdominal pressure can rupture the diaphragm
      d. Shoulder restraints
         (1) Benefits
            (a) Prevents
               i) Forward motion of the upper torso in frontal impact collisions
               ii) Hyper flexion of the upper torso around the lap belts preventing spinal injuries

(b) Moves the upper torso with the vehicle in lateral impact collisions
(2) Limitations
(a) If worn without the lap belt neck injuries can occur
(b) Lessened benefit if the seat is very close to the dash or steering column
e. Air bags
(1) Benefits
(a) Supplemental protection
(b) Frontal impact protection only with frontal bags
(2) Limitations
(a) Minimally effective alone
(b) Can produce significant injuries if too close to the occupant
i) Bag expansion
ii) Protective cover into the face or chest
(c) Projects standing children into the seat producing cervical spine fractures
(d) Facial and forearm abrasions
(e) Deployed air bag may hide structural damage to the vehicle that may aid in assessment
f. Child safety seats
(1) Age and types
(2) Proper use
(3) Injury patterns
(4) Proper use with airbags

E. Motorcycle collisions
1. Frontal impact
a. Bike stops
b. Occupant continues forward
(1) Impacts parts of the bike
(a) Face
(b) Chest
(c) Abdomen
(d) Upper legs (femur)
(2) Ejected over the bike
(a) Into vehicle
(b) Onto ground
(c) Into objects in the pathway
(3) Injuries
(a) C-spine fractures
(b) Torso
i) Compression injuries
a) Solid organ crush
b) Hollow organ rupture (e.g. lungs)

ii) Deceleration (sheer injuries)
a) Aorta
b) Pedicled organs
(c) Compound tibia/ fibula fractures

2. Angular impact
a. Collapse of bike onto vehicle
(1) Legs trapped between bike and vehicle
(2) Open fracture and/or dislocations
b. Lateral motion of torso into vehicle
c. Injuries
(1) Cervical spine
(a) Similar to lateral impact in vehicle
(2) Torso
(a) Compression
i) Lateral chest
ii) Lateral abdomen
(b) Deceleration
i) Aorta
ii) Pedicled organs

3. Protection
a. Head
(1) Helmet
(a) 300% increase brain injury without helmet
(b) Spine
i) Small protection
ii) No increase
b. Skin
(1) Leathers
(2) Very protective during slides on asphalt
c. Ankles and feet
(1) Strong boots

F. Pedestrian verses motor vehicle
1. Injuries patterns depends on
a. Height
b. Body area facing impact
2. Three phases
a. Vehicle pedestrian impact
(1) Legs
(a) Feet stay in place on asphalt
(b) Legs pushed by bumper
(c) Torso moves after the legs
(2) Torso
(a) Pelvis
(b) Crushed by front of vehicle
(c) Lateral or posterior angulation

i) Lumbar fractures
ii) Thoracic fractures

b. Pedestrian rotates onto hood
(1) Impact onto torso
(a) Compression injuries
(b) Acceleration (shear) injures
(2) Cervical spine
(a) Severe flexion or lateral flexion
(b) Torsion
(c) Fractures and dislocations

c. Pedestrian rolls off onto the ground (asphalt)
(1) Beside vehicle
(a) Impact into the ground as fall from height
(2) In front of vehicle
(a) Run over by the vehicle
(b) Dragged by the vehicle

G. Falls
1. Factors
a. Height of fall
b. Surface of the impact
c. Objects struck during the fall
d. Body part of first impact
2. Feet first
a. Impact onto calcaneus
b. Continued motion of the torso
(1) Ankles, knees, femur
(2) Acetabulum, pelvis
(3) Spine
(a) Break the “S”
(b) Arch
i) Convexity stretched & opened
ii) Concavity compressed
(4) Torso
(a) Deceleration (shear)
i) Liver
ii) Kidney
iii) Spleen
iv) Aorta
3. Head first
a. Compression
(1) Skull fracture
(2) Brain
(a) Contusion
(b) Laceration
(3) Spine

b. Deceleration (shear)
(1) Aorta
(2) Kidney
(3) Other

4. Parallel to ground
a. Compression
(1) All parts of the impact

V. Penetrating injuries
A. Energy exchange
1. Number of particles involved
a. Density of tissue
(1) Gas
(a) Lung
(b) Gastrointestinal tract
(2) Liquid
(a) Blood vessels
(b) Muscle
(c) Solid organs
i) Spleen
ii) Liver
iii) Kidney
iv) Other
(3) Solid
(a) Bone
b. Area of interaction
(1) Deformation of bullet
(2) Tumble
(3) Fragmentation

2. Cavitation
a. Permanent
(1) Visible when examined
(2) Crushed tissue
b. Temporary
(1) Compression wave of tissue particles
(2) Away from the pathway of the bullet
(3) Lasts only a few microseconds
(4) Tissue damage produced by stretch

3. Available energy
a. $KE = M/2 \times V^2$
(1) Velocity more important than the mass
b. Mass x acceleration = FORCE = mass x deceleration
(1) Then energy used to place the mass in motion must be completely exchanged into the body tissues to stop the mass
c. Energy potential

(1) Continuum of energy increase
(2) Can be broken down into artificial but workable groups
(3) Energy
(a) Low energy objects
i) Hand driven
a) Knife
b) Ice pick
c) Ax
d) Other
ii) Minimal cavitation
iii) Damage only by cutting edge
(b) Medium energy
i) Muzzle velocity > 1500 feet/ second
ii) Hand guns, low power rifle
iii) Small projectile
iv) Cavitation 6-10 x bullet frontal area
(c) High energy
i) Muzzle velocity < 1500 feet/ second
ii) Military high velocity small caliber weapons
a) Examples (M16, AK 47/74)
b) Other
iii) Cavitation 20-30 x frontal area of missile
(d) Implications of soft body armor

B. Anatomy
1. Organs injured
2. Pathway of missile
a. Entrance wound
(1) Hole is crushed inward
(2) Round or oval shaped
(3) Rim
(a) Dark
(b) 1-2 mm width
(c) Produced by grease and other substance on the bullet
(4) Abrasion
(a) Produced by spinning of the bullet
(b) Largest with greatest contact of skin
i) Larger when impact is at an angle
(5) Burn
(a) Flame from barrel
(b) End of weapon 4-6 inches from the skin
b. Exit wound
(1) Pushed outward
(2) Stellate or slit

VI. Blast

A. Introduction
   1. The blast effect is broken down in to three phases depending on the type of force that occurs during that phase
   2. Each phase has a different energy pattern

B. Phases
   1. Primary
      a. Pressure wave of the blast
         (1) Major effect on gas containing organs
            (a) Organ systems
               i) Lungs
               ii) Intestinal tract
            (b) Pathology
               i) Rupture of the organ
            (c) Air emboli
      b. Heat wave
         (1) Burns on unprotected part of body
         (2) Skin burns
         (3) Eye burns
   2. Secondary
      a. Struck by flying particles
         (1) Glass
         (2) Bricks
         (3) Wood
         (4) Metal
      b. Pathology
         (1) Compression
         (2) Lacerations
   3. Tertiary
      a. Patient becomes flying object
         (1) Impact into other objects
         (2) Similar to falls

UNIT TERMINAL OBJECTIVE

4-2 the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and assessment findings to formulate a field impression and implement the treatment plan for the patient with shock or hemorrhage.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-2.1 Describe the epidemiology, including the morbidity/ mortality and prevention strategies, for shock and hemorrhage. (C-1)
4-2.2 Discuss the anatomy and physiology of the cardiovascular system. (C-1)
4-2.3 Predict shock and hemorrhage based on mechanism of injury. (C-1)
4-2.4 Discuss the various types and degrees of shock and hemorrhage. (C-1)
4-2.5 Discuss the pathophysiology of hemorrhage and shock. (C-1)
4-2.6 Discuss the assessment findings associated with hemorrhage and shock. (C-1)
4-2.7 Identify the need for intervention and transport of the patient with hemorrhage or shock. (C-1)
4-2.8 Discuss the treatment plan and management of hemorrhage and shock. (C-1)
4-2.9 Discuss the management of external hemorrhage. (C-1)
4-2.10 Differentiate between controlled and uncontrolled hemorrhage. (C-3)
4-2.11 Differentiate between the administration rate and amount of IV fluid in a patient with controlled versus uncontrolled hemorrhage. (C-3)
4-2.12 Relate internal hemorrhage to the pathophysiology of compensated and decompensated hemorrhagic shock. (C-3)
4-2.13 Relate internal hemorrhage to the assessment findings of compensated and decompensated hemorrhagic shock. (C-3)
4-2.14 Discuss the management of internal hemorrhage. (C-1)
4-2.15 Define shock based on aerobic and anaerobic metabolism. (C-1)
4-2.16 Describe the incidence, morbidity, and mortality of shock. (C-1)
4-2.17 Describe the body's physiologic response to changes in perfusion. (C-1)
4-2.18 Describe the effects of decreased perfusion at the capillary level. (C-1)
4-2.19 Discuss the cellular ischemic phase related to hemorrhagic shock. (C-1)
4-2.20 Discuss the capillary stagnation phase related to hemorrhagic shock. (C-1)
4-2.21 Discuss the capillary washout phase related to hemorrhagic shock. (C-1)
4-2.22 Discuss the assessment findings of hemorrhagic shock. (C-1)
4-2.23 Relate pulse pressure changes to perfusion status. (C-3)
4-2.24 Relate orthostatic vital sign changes to perfusion status. (C-3)
4-2.25 Define compensated and decompensated hemorrhagic shock. (C-1)
4-2.26 Discuss the pathophysiological changes associated with compensated shock. (C-1)
4-2.27 Discuss the assessment findings associated with compensated shock. (C-1)
4-2.28 Identify the need for intervention and transport of the patient with compensated shock. (C-1)
4-2.29 Discuss the treatment plan and management of compensated shock. (C-1)
4-2.30 Discuss the pathophysiological changes associated with decompensated shock. (C-1)
4-2.31 Discuss the assessment findings associated with decompensated shock. (C-1)
4-2.32 Identify the need for intervention and transport of the patient with decompensated shock. (C-1)
4-2.33 Discuss the treatment plan and management of the patient with decompensated shock. (C-1)
4-2.34 Differentiate between compensated and decompensated shock. (C-3)
4-2.35 Relate external hemorrhage to the pathophysiology of compensated and decompensated hemorrhagic shock. (C-3)

4-2.36 Relate external hemorrhage to the assessment findings of compensated and decompensated hemorrhagic shock. (C-3)
4-2.37 Differentiate between the normotensive, hypotensive, or profoundly hypotensive patient. (C-3)
4-2.38 Differentiate between the administration of fluid in the normotensive, hypotensive, or profoundly hypotensive patient. (C-3)
4-2.39 Discuss the physiologic changes associated with the pneumatic anti-shock garment (PASG). (C-1)
4-2.40 Discuss the indications and contraindications for the application and inflation of the PASG. (C-1)
4-2.41 Apply epidemiology to develop prevention strategies for hemorrhage and shock. (C-1)
4-2.42 Integrate the pathophysiological principles to the assessment of a patient with hemorrhage or shock. (C-3)
4-2.43 Synthesize assessment findings and patient history information to form a field impression for the patient with hemorrhage or shock. (C-3)
4-2.44 Develop, execute and evaluate a treatment plan based on the field impression for the hemorrhage or shock patient. (C-3)

AFFECTIVE OBJECTIVES
None identified for this unit.

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-2.45 Demonstrate the assessment of a patient with signs and symptoms of hemorrhagic shock. (P-2)
4-2.46 Demonstrate the management of a patient with signs and symptoms of hemorrhagic shock. (P-2)
4-2.47 Demonstrate the assessment of a patient with signs and symptoms of compensated hemorrhagic shock. (P-2)
4-2.48 Demonstrate the management of a patient with signs and symptoms of compensated hemorrhagic shock. (P-2)
4-2.49 Demonstrate the assessment of a patient with signs and symptoms of decompensated hemorrhagic shock. (P-2)
4-2.50 Demonstrate the management of a patient with signs and symptoms of decompensated hemorrhagic shock. (P-2)
4-2.51 Demonstrate the assessment of a patient with signs and symptoms of external hemorrhage. (P-2)
4-2.52 Demonstrate the management of a patient with signs and symptoms of external hemorrhage. (P-2)
4-2.53 Demonstrate the assessment of a patient with signs and symptoms of internal hemorrhage. (P-2)
4-2.54 Demonstrate the management of a patient with signs and symptoms of internal hemorrhage. (P-2)

DECLARATIVE

I. Pathophysiology, assessment, and management of hemorrhage
  A. Hemorrhage
    1. Epidemiology
      a. Incidence
      b. Mortality/ morbidity
      c. Prevention strategies
    2. Pathophysiology
      a. Location
        (1) External
          (a) Controlled
          (b) Uncontrolled
        (2) Internal
          (a) Trauma
          (b) Non-trauma
            i) Common sites
            ii) Uncommon sites
          (c) Controlled
          (d) Uncontrolled
      b. Anatomical type
        (1) Arterial
        (2) Venous
        (3) Capillary
      c. Timing
        (1) Acute
        (2) Chronic
      d. Severity
        (1) Amounts of blood loss tolerated by
          (a) Adults
          (b) Children
          (c) Infants
      e. Physiological response to hemorrhage
        (1) Clotting
        (2) Localized vasoconstriction
      f. Stages of hemorrhage
        (1) Stage 1
          (a) Up to 15% intravascular loss
          (b) Compensated by constriction of vascular bed
          (c) Blood pressure maintained
          (d) Normal pulse pressure, respiratory rate, and renal output
          (e) Pallor of the skin
          (f) Central venous pressure low to normal
        (2) Stage 2
          (a) 15-25% intravascular loss
          (b) Cardiac output cannot be maintained by arteriolar constriction
          (c) Reflex tachycardia
          (d) Increased respiratory rate

(e) Blood pressure maintained
(f) Catecholamines increase peripheral resistance
(g) Increased diastolic pressure
(h) Narrow pulse pressure
(i) Diaphoresis from sympathetic stimulation
(j) Renal output almost normal

(3) Stage 3
(a) 25-35% intravascular loss
(b) Classic signs of hypovolemic shock
i) Marked tachycardia
ii) Marked tachypnea
iii) Decreased systolic pressure
iv) 5-15 ml per hour urine output
v) Alteration in mental status
vi) Diaphoresis with cool, pale skin

(4) Stage 4
(a) Loss greater than 35%
(b) Extreme tachycardia
(c) Pronounced tachypnea
(d) Significantly decreased systolic blood pressure
(e) Confusion and lethargy
(f) Skin is diaphoretic, cool, and extremely pale

3. Assessment
a. Bright red blood from wound, mouth, rectum or other orifice
b. Coffee ground appearance of vomitus
c. Melena
d. Hematochezia
e. Dizziness or syncope on sitting or standing
f. Orthostatic hypotension
g. Signs and symptoms of hypovolemic shock

4. Management
a. Airway and ventilatory support
b. Circulatory support
(1) Bleeding from nose or ears after head trauma
(a) Refrain from applying pressure
(b) Apply loose sterile dressing to protect from infection
(2) Bleeding from other areas
(a) Control bleeding
i) Direct pressure
ii) Elevation if appropriate
iii) Pressure points
iv) Tourniquet
v) Splinting
vi) Packing of large gaping wounds with sterile dressings
vii) PASG
(b) Apply sterile dressing and pressure bandage
(3) Transport considerations
(4) Psychological support/ communication strategies

II. Shock
- A. Epidemiology
  - 1. Mortality/ morbidity
  - 2. Prevention strategies
  - 3. Pathophysiology
    - a. Perfusion depends on cardiac output (CO), systemic vascular resistance (SVR) and transport of oxygen
      - (1) CO = HR X SV
        - (a) HR - heart rate
        - (b) SV - stroke volume
      - (2) BP = CO X SVR
      - (3) Hypoperfusion can result from
        - (a) Inadequate cardiac output
        - (b) Excessive systemic vascular resistance
        - (c) Inability of red blood cells to deliver oxygen to tissues
    - b. Compensation for decreased perfusion
      - (1) Occurrence of event resulting in decreased perfusion, e.g., blood loss, myocardial infarction, loss of vasomotor tone or tension pneumothorax
      - (2) Baroreceptors sense decreased flow and activate vasomotor center
        - (a) Normally stimulated between 60-80 mm Hg systolic (lower in children)
        - (b) Located in carotid sinuses and aortic arch
        - (c) Arterial pressure drop decreases stretch
          - i) Nerve impulse through Vagus and Hering's nerve to glossopharyngeal nerve
          - ii) Impulse transmitted to vasomotor center
          - iii) Frequency of inhibitory impulses decreases
          - iv) Increase in vasomotor activity
          - v) Sympathetic nervous system stimulated
        - (iv) Decrease in systolic less than 80 mmHg stimulates vasomotor center to increase arterial pressure
      - (3) Chemoreceptors are stimulated by decrease in PaO_2 and increase in $PaCO_2$
      - (4) Sympathetic nervous system
      - (5) Adrenal medulla glands secrete epinephrine and norepinephrine
        - (a) Epinephrine
          - i) Alpha 1
            - a) Vasoconstriction
            - b) Increase in peripheral vascular resistance
            - c) Increased afterload from arteriolar constriction
          - ii) Alpha 2 regulated release of alpha 1
          - iii) Beta 1
            - a) Positive chronotropy
            - b) Positive inotropy
            - c) Positive dromotropy
          - iv) Beta 2
            - a) Bronchodilation

b) Gut smooth muscle dilation
(b) Norepinephrine
i) Primarily alpha 1 and alpha 2
a) Vasoconstriction
b) Increase in peripheral vascular resistance
c) Increased afterload from arteriolar constriction
(6) Arginine vasopressin (AVP)
(a) Also known as antidiuretic hormone (ADH)
(b) Released from anterior pituitary gland
(c) Effects
i) Increases free water absorption in distal tubule and collecting ducts of kidney
ii) Decreases urine output
iii) Splanchnic vascular constriction
(7) Renin-angiotensin system
(a) Renin released from kidney arteriole
(b) Renin and angiotensinogen combine in renal arteriole to produce angiotensin I
(c) Angiotensin I converted to angiotensin II by angiotensin converting enzyme
(d) Effects of angiotensin II
i) Potent vasoconstrictor
ii) Sodium reabsorption decreases urine output
iii) Positive inotrope and chronotrope
(8) Aldosterone
(a) Defends fluid volume
(b) Secreted by cells of adrenal cortex in response to stress
(c) Promotes sodium reabsorption and water retention in kidney
(d) Reduces urine output
(9) Insulin
(a) Secretion is diminished by circulating epinephrine
(b) Impaired effect on peripheral tissue
(c) Contributes to hyperglycemia seen following injury and volume loss
(10) Glucagon
(a) Stimulated to be released by epinephrine
(b) Promotes
i) Liver glycogenolysis
ii) Gluconeogenesis
iii) Amino acid uptake for conversion into glucose
iv) Transfer of fatty acid into mitochondria
(11) ACTH (adrenocorticotropic hormone)-cortisol system
(a) ACTH release stimulates the release of cortisol from the adrenal cortex of kidney
(b) Cortisol increases glucose production by inhibiting enzymes that break down glucose
(12) Growth hormone
(a) Secreted by anterior pituitary gland

(b) Early effects of growth hormone
i) Promotes uptake of glucose and amino acids in muscle
ii) Stimulates protein synthesis
(13) Failure of compensation to preserve perfusion
(14) Preload decreases
(15) Cardiac output decreases
(16) Myocardial blood supply and oxygenation decrease
(a) Myocardial perfusion decreases
(b) Cardiac output decreases further
(c) Coronary artery perfusion decreases
(d) Myocardial ischemia
(17) Capillary and cellular changes
(a) Ischemia
i) Minimal blood flow to capillaries
ii) Cells go from aerobic to anaerobic metabolism
(b) Stagnation
(c) Precapillary sphincter relaxes in response to
a) Lactic acid
b) Vasomotor center failure
c) Increased carbon dioxide
i) Postcapillary sphincters remain constricted
ii) Capillaries engorge with fluid
iii) Anaerobic metabolism continues, increasing lactic acid production
a) Aggregation of red blood cells and formation of microemboli
b) Potent vasodilator
c) Destroys capillary cell membrane
iv) Plasma leaks from capillaries
v) Interstitial fluid increases
a) Distance from capillary to cell increases
b) Oxygen transport decreases secondary to increased capillary-cell distance
vi) Myocardial toxin factor released by ischemic pancreas
(d) Washout
i) Postcapillary sphincter relaxes
ii) Hydrogen, potassium, carbon dioxide, thrombosed - erythrocytes wash out
iii) Metabolic acidosis results
iv) Cardiac output drops further

c. Stages of shock
(1) Compensated or nonprogressive
(a) Characterized by signs and symptoms of early shock
(b) Arterial blood pressure is normal or high
(c) Treatment at this stage will typically result in recovery
(2) Decompensated or progressive
(a) Characterized by signs and symptoms of late shock
(b) Arterial blood pressure is abnormally low

(c) Treatment at this stage will sometimes result in recovery
(3) Irreversible
(a) Characterized by signs and symptoms of late shock
(b) Arterial blood pressure is abnormally low
(c) Even aggressive treatment at this stage does not result in recovery
d. Etiologic classifications
(1) Hypovolemic
(a) Hemorrhage
(b) Plasma loss
(c) Fluid and electrolyte loss
(d) Endocrine
(2) Distributive (vasogenic)
(a) Increased venous capacitance
(b) Low resistance, vasodilation
(3) Cardiogenic
(a) Myocardial insufficiency
(b) Filling or outflow obstruction (obstructive)
(4) Spinal neurogenic shock
(a) Refers to temporary loss of all types of spinal cord function distal to injury
i) Flaccid paralysis distal to injury site
ii) Loss of bladder and bowel control
iii) Priapism
iv) Loss of thermoregulation
(b) Does not always involve permanent primary injury
(5) Spinal shock
(a) Also called spinal vascular shock
(b) Temporary loss of the autonomic function of the cord at the level of injury which controls cardiovascular function
(c) Presentations includes
i) Loss of sympathetic tone
ii) Relative hypotension
a) Systolic pressure 80 - 100 mmHg
iii) Skin is pink, warm and dry
a) Due to cutaneous vasodilation
iv) Relative bradycardia
(d) Occurrence is rare
(e) Shock presentation is usually the result of hidden volume loss
i) Chest injuries
ii) Abdominal injuries
iii) Other violent injuries
(f) Treatment
i) Focus primarily on volume replacement
4. Assessment - hypovolemic shock due to hemorrhage
(1) Early or compensated
(a) Tachycardia
(b) Pale, cool skin

(c) Diaphoresis
(d) Level of consciousness
i) Normal
ii) Anxious or apprehensive
(e) Blood pressure maintained
(f) Narrow pulse pressure
i) Pulse pressure is the difference between the systolic and diastolic pressures, i.e., pulse pressure = systolic - diastolic
ii) Pulse pressure reflects the tone of the arterial system and is more sensitive to changes in perfusion than the systolic or diastolic alone
(g) Positive orthostatic tilt test
(h) Dry mucosa
(i) Complaints of thirst
(j) Weakness
(k) Possible delay of capillary refill

(2) Late or progressive
(a) Extreme tachycardia
(b) Extreme pale, cool skin
(c) Diaphoresis
(d) Significant decrease in level of consciousness
(e) Hypotension
(f) Dry mucosa
(g) Nausea
(h) Cyanosis with white waxy looking skin

a. Differential shock assessment findings
(1) Shock is assumed to be hypovolemic until proven otherwise
(2) Cardiogenic shock
(a) Differentiated from hypovolemic shock by one or more of the following
i) Chief complaint (chest pain, dyspnea, tachycardia)
ii) Heart rate (bradycardia or excessive tachycardia)
iii) Signs of congestive heart failure (jugular vein distention, rales)
iv) Dysrhythmias
(b) Distributive shock
(c) Differentiated from hypovolemic shock by presence of one or more of following
i) Mechanism that suggests vasodilation, e.g., spinal cord injury, drug overdose, sepsis, anaphylaxis
ii) Warm, flushed skin, especially in dependent areas
iii) Lack of tachycardia response (not reliable, though, since significant number of hypovolemic patients never become tachycardic)
(d)) Obstructive shock
i) Differentiated from hypovolemic shock by presence of signs and symptoms suggestive of

ii) Cardiac tamponade
iii) Tension pneumothorax

5. Management/ treatment plan
   a. Airway and ventilatory support
      (1) Ventilate and suction as necessary
      (2) Administer high concentration oxygen
      (3) Reduce increased intrathoracic pressure in tension pneumothorax
   b. Circulatory support
      (1) Hemorrhage control
      (2) Intravenous volume expanders
         (a) Types
            i) Isotonic solutions
            ii) Hypertonic solutions
            iii) Synthetic solutions
            iv) Blood and blood products
            v) Experimental solutions
            vi) Blood substitutes
         (b) Rate of administration
            i) External hemorrhage that can be controlled
            ii) External hemorrhage that can not be controlled
            iii) Internal hemorrhage
               a) Blunt trauma
               b) Penetrating trauma
      (3) Pneumatic anti-shock garment
         (a) Effects
            i) Increased arterial blood pressure above garment
            ii) Increased systemic vascular resistance
            iii) Immobilization of pelvis and possibly lower extremities
            iv) Increased intra-abdominal pressure
         (b) Mechanism
            i) Increases systemic vascular resistance through direct compression of tissues and blood vessels
            ii) Negligible autotransfusion effect
         (c) Indications
            i) Hypoperfusion with unstable pelvis
            ii) Conditions of decreased SVR not corrected by other means
            iii) As approved locally, other conditions characterized by hypoperfusion with hypotension
            iv) Research studies
         (d) Contraindications
            i) Advanced pregnancy (no inflation of abdominal compartment)
            ii) Object impaled in abdomen or evisceration (no inflation of abdominal compartment)
            iii) Ruptured diaphragm
            iv) Cardiogenic shock
            v) Pulmonary edema

(4) Needle chest decompression of tension pneumothorax to improve impaired cardiac output
(5) Recognize the need for expeditious transport of suspected cardiac tamponade for pericardiocentesis

c. Pharmacological interventions
(1) Hypovolemic shock
(a) Volume expanders
(2) Cardiogenic shock
(a) Volume expanders
(b) Positive cardiac inotropes
(c) Vasoconstrictor
(d) Rate altering medications
(3) Distributive shock
(a) Volume expanders
(b) Positive cardiac inotropes
(c) Vasoconstriction
(d) PASG
(4) Obstructive shock
(a) Volume expanders
(5) Spinal shock
(a) Volume expanders

d. Psychological support/communication strategies
e. Transport considerations
(1) Indications for rapid transport
(2) Indications for transport to a trauma center
(3) Considerations for air medical transportation

III. Integration

UNIT TERMINAL OBJECTIVE

4-3 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with soft tissue trauma.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-3.1 Describe the incidence, morbidity, and mortality of soft tissue injures. (C-1)
4-3.2 Describe the layers of the skin, specifically: (C-1)
- a. Epidermis and dermis (cutaneous)
- b. Superficial fascia (subcutaneous)
- c. Deep fascia

4-3.3 Identify the major functions of the integumentary system. (C-1)
4-3.4 Identify the skin tension lines of the body. (C-1)
4-3.5 Predict soft tissue injuries based on mechanism of injury. (C-1)
4-3.6 Discuss the pathophysiology of wound healing, including: (C-1)
1. Hemostasis
2. Inflammation phase
3. Epithelialization
4. Neovascularization
5. Collagen synthesis

4-3.7 Discuss the pathophysiology of soft tissue injuries. (C-2)
4-3.8 Differentiate between the following types of closed soft tissue injuries: (C-3)
a. Contusion
2. Hematoma
3. Crush injuries

4-3.9 Discuss the assessment findings associated with closed soft tissue injuries. (C-1)
4-3.10 Discuss the management of a patient with closed soft tissue injuries. (C-2)
4-3.11 Discuss the pathophysiology of open soft tissue injuries. (C-2)
4-3.12 Differentiate between the following types of open soft tissue injuries: (C-3)
a. Abrasions
2. Lacerations
3. Major arterial lacerations
4. Avulsions
5. Impaled objects
6. Amputations
7. Incisions
8. Crush injuries
9. Blast injuries

10. Penetrations/ punctures

4-3.13 Discuss the incidence, morbidity, and mortality of blast injuries. (C-1)

4-3.14 Predict blast injuries based on mechanism of injury, including: (C-2)
a. Primary
2. Secondary
3. Tertiary

4-3.15 Discuss types of trauma including: (C-1)
a. Blunt
2. Penetrating
3. Barotrauma
4. Burns

4-3.16 Discuss the pathophysiology associated with blast injuries. (C-1)

4-3.17 Discuss the effects of an explosion within an enclosed space on a patient. (C-1)

4-3.18 Discuss the assessment findings associated with blast injuries. (C-1)

4-3.19 Identify the need for rapid intervention and transport of the patient with a blast injury. (C-1)

4-3.20 Discuss the management of a patient with a blast injury. (C-1)

4-3.21 Discuss the incidence, morbidity, and mortality of crush injuries. (C-1)

4-3.22 Define the following conditions: (C-1)
1. Crush injury
2. Crush syndrome
3. Compartment syndrome

4-3.23 Discuss the mechanisms of injury in a crush injury. (C-1)

4-3.24 Discuss the effects of reperfusion and rhabdomyolysis on the body. (C-1)

4-3.25 Discuss the assessment findings associated with crush injuries. (C-1)

4-3.26 Identify the need for rapid intervention and transport of the patient with a crush injury. (C-1)

4-3.27 Discuss the management of a patient with a crush injury. (C-1)

4-3.28 Discuss the pathophysiology of hemorrhage associated with soft tissue injuries, including: (C-2)
1. Capillary
2. Venous
3. Arterial

4-3.29 Discuss the assessment findings associated with open soft tissue injuries. (C-1)
4-3.30 Discuss the assessment of hemorrhage associated with open soft tissue injuries. (C-1)
4-3.31 Differentiate between the various management techniques for hemorrhage control of open soft tissue injuries, including: (C-3)
- a. Direct pressure
- 2. Elevation
- 3. Pressure dressing
- 4. Pressure point
- 5. Tourniquet application

4-3.32 Differentiate between the types of injuries requiring the use of an occlusive versus non-occlusive dressing. (C-3)
4-3.33 Identify the need for rapid assessment, intervention and appropriate transport for the patient with a soft tissue injury. (C-2)
4-3.34 Discuss the management of the soft tissue injury patient. (C-2)
4-3.35 Define and discuss the following: (C-1)
- a. Dressings
  - 1. Sterile
  - 2. Non-sterile
  - 3. Occlusive
  - 4. Non-occlusive
  - 5. Adherent
  - 6. Non-adherent
  - 7. Absorbent
  - 8. Non-absorbent
  - 9. Wet
  - 10. Dry
- 2. Bandages
  - 1. Absorbent
  - 2. Non-absorbent
  - 3. Adherent
  - 4. Non-adherent
- 3. Tourniquet

4-3.36 Predict the possible complications of an improperly applied dressing, bandage, or tourniquet. (C-2)
4-3.37 Discuss the assessment of wound healing. (C-1)
4-3.38 Discuss the management of wound healing. (C-1)
4-3.39 Discuss the pathophysiology of wound infection. (C-1)
4-3.40 Discuss the assessment of wound infection. (C-1)
4-3.41 Discuss the management of wound infection. (C-1)

4-3.42 Integrate pathophysiological principles to the assessment of a patient with a soft tissue injury. (C-3)
4-3.43 Formulate treatment priorities for patients with soft tissue injuries in conjunction with: (C-3)
a. Airway/ face/ neck trauma
2. Thoracic trauma (open/ closed)
3. Abdominal trauma
4-3.44 Synthesize assessment findings and patient history information to form a field impression for the patient with soft tissue trauma. (C-3)
4-3.45 Develop, execute, and evaluate a treatment plan based on the field impression for the patient with soft tissue trauma. (C-3)

AFFECTIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-3.46 Defend the rationale explaining why immediate life-threats must take priority over wound closure. (A-3)
4-3.47 Defend the management regimens for various soft tissue injuries. (A-3)
4-3.48 Defend why immediate life-threatening conditions take priority over soft tissue management. (A-3)
4-3.49 Value the importance of a thorough assessment for patients with soft tissue injuries. (A-3)
4-3.50 Attend to the feelings that the patient with a soft tissue injury may experience. (A-2)
4-3.51 Appreciate the importance of good follow-up care for patients receiving sutures. (A-2)
4-3.52 Understand the value of the written report for soft tissue injuries, in the continuum of patient care. (A-2)

PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-3.53 Demonstrate the assessment and management of a patient with signs and symptoms of soft tissue injury, including: (P-2)
1. Contusion
2. Hematoma
3. Crushing
4. Abrasion
5. Laceration
6. Avulsion
7. Amputation

8. Impaled object
9. Penetration/ puncture
10. Blast

DECLARATIVE

I. Introduction
  A. Epidemiology
    1. Incidence
    2. Mortality/ morbidity
    3. Risk factors
    4. Prevention strategies
  B. Body substance isolation review
    1. Risks from exposure to body substances
      a. Bloodborne pathogens
        (1) HIV
        (2) HBV
        (3) Other bloodborne pathogens
      b. Other body substances posing risk
    2. Relationship to body substance isolation
      a. Universal precautions
        (1) Gloves
        (2) Hand washing
        (3) Protective eyewear
        (4) Masks
        (5) Gowns
        (6) Handling and disposal of sharps
      b. Disposal of contaminated materials
  C. Anatomy and physiology review
    1. Layers
      a. Cutaneous layer
        (1) Epidermis
          (a) Stratum germinativum (Basal Layer)
          (b) Stratum corneum
        (2) Dermis
          (a) Fibroblasts
          (b) Macrophages
          (c) Mast cells
          (d) Lymphocytes
          (e) Papillary dermis
          (f) Reticular dermis
      b. Subcutaneous layer (superficial fascia)
        (1) Loose connective tissue
        (2) Fat
          (a) Insulation
          (b) Protection from trauma
      c. Deep fascia

(1) Thick, dense layer of fibrous tissue
(2) Support and protect underlying structures

2. Functions
   a. Protection against mechanical trauma
   b. Regulation of body temperature
   c. Sensory function
      (1) Pain
      (2) Touch
      (3) Heat
      (4) Cold
   d. Protection against bacterial invasion
   e. Maintenance of fluid balance
3. Skin tension lines
   a. Static tension
      (1) Constant force due to taut nature of skin
      (2) Effects on scar formation
      (3) Consideration in wound debridement and revision
      (4) Consideration in foreign body removal
   b. Dynamic tension
      (1) Caused by underlying muscle contraction
      (2) Effects on scar formation
      (3) Consideration in wound debridement and revision
      (4) Consideration in foreign body removal
4. Process of normal wound healing
   a. Hemostasis of wound healing
      (1) Injury causes changes in normal skin anatomy
      (2) Reflex vasoconstriction for up to 10 minutes
      (3) Clotting process begins
   b. Inflammatory phase
      (1) Role of granulocytes
      (2) Role of lymphocytes
      (3) Role of macrophages
   c. Epithelialization phase
      (1) Wound healing within 12 hours
      (2) Healing through re-establishment of skin layers
   d. Neovascularization
      (1) Role of new vessel formation
      (2) Neovascularization as soon as 3 days after, lasting a total of 21 days
      (3) New vessel formation

e. Collagen synthesis
   (1) Role of fibroblasts in collagen synthesis
   (2) Time factors involved with collagen fibers
   (3) Process of collagen lysis and wound healing
   (4) Time table for the healing and tensile strength of wound

5. Alteration of wound healing
   a. Anatomic factors
      (1) Body region
      (2) Static skin tension
      (3) Dynamic skin tension
      (4) Pigmented skin
      (5) Oily skin
   b. Concurrent drug use
      (1) Corticosteriods
      (2) NSAID
      (3) Penicillin
      (4) Colchicine
      (5) Anticoagulants
      (6) Antineoplastic agents
   c. Medical conditions and diseases
      (1) Advanced age
      (2) Severe alcoholism
      (3) Acute uremia
      (4) Diabetes
      (5) Hypoxia
      (6) Severe anemia
      (7) PVD
      (8) Malnutrition
      (9) Advanced cancer
      (10) Hepatic failure
      (11) Cardiovascular disease
   d. High risk wounds
      (1) Bites (human and animal)
      (2) Foreign bodies
      (3) Wounds contaminated with organic matter
      (4) Injection wounds
      (5) Wounds with significant devitalized tissue
      (6) Crush wounds
      (7) Any wound in immunocompromised patients
      (8) Any wound in patients with poor peripheral circulation
6. Abnormal scar formation

a. Keloid
(1) Excessive accumulation of scar tissue that extends beyond original wound borders
(2) More common in darkly pigmented individuals
(3) Most common locations
(a) Ears
(b) Upper extremities
(c) Lower abdomen
(d) Sternum
b. Hypertrophic scar formation
(1) Excessive accumulation of scar tissue confined within the original wound borders
(2) More common in areas of high tissue stress, such as flexion creases across joints
c. Wounds requiring closure
(1) Cosmetic regions (face, lip, eyebrow, etc.
(2) Gaping wounds
(3) Wounds over tension areas
(4) Degloving injuries
(5) Ring injuries
(6) Skin tearing

II. Pathophysiology and assessment of soft tissue injuries
A. Identification of closed soft tissue injuries
1. Contusion
a. Epidermis remains intact
b. Cells damaged and blood vessels in dermis are torn
c. Swelling and pain typically present - may occur up to 24 to 48 hours later
d. Blood accumulation causes ecchymosis
2. Hematoma
a. Collection of blood beneath skin
b. Larger amount of tissue damage as compared to contusion
c. Larger vessels are damaged
d. May lose one or more liters of blood in confined space
3. Crush injuries
a. Crushing force applied to body area
b. Can cause internal organ rupture
c. Associated with severe fractures
d. Overlying skin may remain intact, but internal bleeding may be severe, with shock

B. Identification of open soft tissue injuries
   1. Abrasions
      a. Outermost layer of skin is damaged by shearing forces
      b. Painful injury
      c. Superficial
      d. No blood, or very little oozing of blood
         (1) Contamination should be expected
   2. Lacerations
      a. Break in skin of varying depth
      b. May be linear (regular) or stellate (irregular)
      c. Jagged wound ends that bleed freely
      d. May occur in isolation or together with other types of soft tissue injury
      e. Caused by forceful impact with a sharp object
      f. Bleeding may be severe
   3. Incisions
      a. Break in skin of varying depth
      b. Similar to laceration except wound ends are smooth and even, not jagged
      c. Tend to heal better than lacerations
      d. Caused by very sharp objects, such as knife, sharp metal, or scalpel
   4. Avulsion
      a. Flap of skin or tissue torn loose or pulled completely off
      b. Avulsed tissue may or may not be viable
   5. Amputations
      a. Involves the extremities or other body parts
      b. Jagged skin and/ or bone edges are typically present at site of amputation
      c. Massive bleeding may be present or bleeding may be limited
      d. Three types of amputations
         (1) Complete
         (2) Partial
         (3) Degloving
   6. Crush injuries
      a. Causes of injuries
         (1) Collapse of masonry or steel structures
            (a) Earthquakes
            (b) Tornadoes
            (c) Construction accidents

(2) Collapse of earth
(a) Mudslides
(b) Earthquakes
(3) Motor vehicle collisions
(4) Warfare injuries
(5) Industrial accidents
(6) Any prolonged compression in a chronic situation
(a) Unconscious person lying on an extremity
(b) Prolonged application of PASG
(c) Improperly applied casts

b. Crush injuries - definitions
(1) Crush injury - injury sustained from a compressive force sufficient to interfere with the normal metabolic function of the involved tissue
(2) Crush syndrome - traumatic rhabdomyolysis; "smiling death"
(3) Systemic manifestations of crush injuries consisting of rhabdomyolysis, electrolyte and acid-base abnormalities, hypovolemia (shock), and acute renal failure
(4) Compartment syndrome - local manifestations of muscle ischemia resulting from compressive forces on a closed space

c. Pathophysiology of crush syndrome
(1) Damage to soft tissue and internal organs
(2) May cause painful, swollen, deformed extremities
(3) External bleeding may be minimal or absent
(4) Internal bleeding may be severe
(5) Reperfusion phenomenon - systemic effects and even microvascular injury occur after the affected tissue is reperfused
(6) Oxygen free radicals
(7) Xanthine oxidase - xanthine oxidase requires two substrates - hypoxanthine and oxygen on reperfusion; oxygen is supplied so xanthine oxidase uses oxygen as an electron acceptor generating the oxygen free radical - oxygen superoxide
(8) Lipid peroxidation - pressure stretch myopathy

(9) High intracellular calcium levels

d. Rhabdomyolysis
   (1) Destruction of muscle
   (2) Influx from extracellular fluid into muscle cells
      (a) Water
      (b) NaCl
      (c) Ca++
   (3) Eflux from muscle to extracellular fluid
      (a) K+
      (b) Purines from disintegrating cell nuclei
      (c) Phosphate
      (d) Lactic acid
      (e) Myoglobin
      (f) Thromboplastin
      (g) Creatine kinase & creatinine
   (4) Consequences - all contribute to development of renal failure
      (a) Hypovolemia - adds to cardiotoxicity
      (b) Hypocalcemia - adds to cardiotoxicity
      (c) Hyperkalemia - adds to cardiotoxicity
      (d) Hyperuricemia
      (e) Hyperphosphatemia
      (f) Metabolic acidosis
      (g) Possible DIC
      (h) Increased levels of serum creatine and creatinine
e. Pathophysiology of compartment syndrome
   (1) Tissue pressure rises above capillary hydrostatic pressure resulting in ischemia to muscle
   (2) Edema of muscle cells develop
   (3) Prolonged ischemia (> 6 to 8 hours) leads to tissue hypoxia and anoxia, and ultimately cell death
   (4) Direct soft tissue trauma adds to the edema and ischemia
f. Renal failure pathogenesis
   (1) Hypovolemia
   (2) Obstructed renal tubules by casts
   (3) Nephrotoxic agents
   (4) Other factors
g. Crush injury clinical presentation

(1) General
(a) Alert to unresponsive
(b) Affected limb may appear almost normal
(2) Local signs and symptoms
(a) Flaccid paralysis and sensory loss that are unrelated to peripheral nerve distribution
(b) May mimic spinal cord injury
(c) Early - rigor of the joint distal to the involved muscles, wooden texture of the affected skin and muscles, and loss of voluntary muscle contraction
(d) Varying combinations of pain, swelling, sensory changes, weakness, and pain on passive stretching of muscles
(e) May have pulses present and warm skin
(3) Compartment syndrome
(a) Pain
(b) Paresthesia
(c) Paresis
(d) Pressure
(e) Passive stretch pain
(f) Pulselessness

7. Blast injuries
a. Causes of blast injuries
(1) Natural gas or gasoline explosions
(2) Firework explosions
(3) Dust within a grain elevator
(4) Terrorism (bombs)
b. Primary injuries
(1) Initial air blast
(2) Compression injuries to air filled organs
(a) Ruptured ear drum
(b) Sinuses
(c) Lungs
(d) Stomach
(e) Intestines
c. Secondary injuries due to flying debris striking victim
d. Tertiary injuries
(1) Victim is thrown from the blast and strikes an object
(2) All can lead to superficial and deep internal

injuries
8. Punctures/ penetrations
   a. Caused by a foreign object that enters the body
   b. Bleeding is minimal or absent if extremity injury
   c. Bleeding may be severe if abdominal or thoracic injury
   d. Underlying damage can be extensive
      (1) Thoracic
         (a) Simple pneumothorax
         (b) Open pneumothorax
         (c) Tension pneumothorax
         (d) Hemothorax
         (e) Pericardial tamponade
         (f) Penetrating heart wound
         (g) Rupture of esophagus
         (h) Rupture of aorta
         (i) Rupture of diaphragm
         (j) Rupture of mainstem bronchus
      (2) Abdominal
         (a) Solid organ damage
         (b) Hollow organ damage
         (c) Peritonitis
            i) Bacterial
            ii) Chemical
         (d) Evisceration
   e. Increased risk of infection/ complications
9. Impaled objects
   a. Specific type of puncture wound
   b. Instrument that caused injury remains impacted in wound
10. Major arterial lacerations
   a. Any of these injuries can involve major arterial lacerations
   b. Bleeding often will be severe
   c. Spurting, bright red blood flow
   d. Artery may spasm which may decrease blood flow
   e. Can result in shock and death if severe enough blood loss

III. Management principles for soft tissue injuries
   A. Treatment priorities
      1. Emphasize scene survey to protect yourself and crew
         a. Have the police ruled out the presence of another

bomb or device?
b. Have the police apprehended the perpetrator?
2. Treat for hypoperfusion (shock)
3. Consider the power of the explosion
4. Internal and external injuries are possible (refer to specific units on specific injuries encountered)
5. Be aware of possibility of multiple trauma
6. Treatment priorities for patient with a soft tissue injury
a. Treatment of life-threatening injury should occur prior to isolated soft tissue trauma
(1) Life-threatening airway deficit
(2) Life-threatening breathing deficit
(3) Life-threatening circulatory deficit
7. Methods of hemorrhage control based on injury severity
a. Direct pressure
(1) General description
(a) Quickest/ efficient means
(2) Pressure applied directly to wound
(a) Dressing and gloved hand
(b) Gloved hand
(3) Physiology of intervention
(a) Limit additional significant blood loss
(b) Promote localized clotting
(4) Indications
(a) Mild hemorrhage
(b) Profuse hemorrhage
(5) Contraindications - none
(6) Assessment of intervention
(a) Positive hemorrhage control
(b) Prevention of additional significant blood loss
(7) Considerations
(a) Never remove dressing once in place
i) Restart bleed
ii) Additional injury
(b) Positive hemorrhage control
i) Secure in place with bandage
(c) Negative hemorrhage control
i) Continue direct pressure
ii) Apply additional dressing
iii) Elevation of extremity with direct pressure

b. Elevation
    (1) General description
        (a) Used concurrent with direct pressure
        (b) Extremity involvement only
        (c) Elevation of extremity
    (2) Physiology of intervention
        (a) Wound above level of heart
        (b) Gravity decreases blood pressure in extremity
        (c) Slow hemorrhage
        (d) Promote localized clotting
    (3) Indications
        (a) Control of hemorrhage
        (b) Failure of direct pressure to control hemorrhage
    (4) Contraindications
        (a) Possible musculoskeletal injury to involved extremity
        (b) Object impaled in involved extremity
        (c) Possible spinal injury
    (5) Assessment of intervention
        (a) Positive hemorrhage control
        (b) Prevention of additional significant blood loss
    (6) Considerations
        (a) Positive control - continue elevation
        (b) Negative control
            i) Continue elevation
            ii) Consider pressure dressing

c. Pressure dressing
    (1) General description
        (a) Dressing firmly wrapped with self adhering roller bandage
        (b) Continuous mechanical pressure
            i) Over injury site
            ii) Above injury site
            iii) Below injury site
    (2) Physiology of intervention
        (a) Limit additional significant blood loss with continuous pressure
        (b) Promote localized clotting
    (3) Indications
        (a) Hemorrhage control

(b) Failure of other methods to control hemorrhage
i) Direct pressure
ii) Elevation
(4) Contraindications - none
(5) Assessment of intervention
(a) Positive control of hemorrhage
(b) Prevent additional significant blood loss
(6) Considerations
(a) Check distal pulse after application
i) Positive pulse - leave in place
ii) Negative pulse - adjust to establish circulation
iii) Some arterial bleeds will stop circulation needed for pulse
(b) Certain body regions not conducive to direct pressure
(c) If bleeding continues adjust with more pressure

d. Pressure points
(1) General description
(a) Site where main artery lies near surface
(b) Direct compression applied to site
i) Brachial artery
ii) Femoral artery
(2) Physiology of intervention
(a) Decrease blood flow to extremity
(b) Limit additional significant blood loss
(c) Promote localized clotting
(3) Indications
(a) Need for hemorrhage control
(b) Failure of other methods of hemorrhage control
i) Direct pressure
ii) Elevation
iii) Pressure dressings
(4) Contraindications - none
(5) Assessment of intervention
(a) Positive hemorrhage control
(b) Prevention of additional significant blood loss
(6) Considerations

(a) Skill needed to locate pressure points
(b) Distal wounds difficult to control with pressure points
(c) Proper application
i) Considerable force needed
ii) Loss of distal pulses

e. Tourniquet application
(1) General description
(a) Last resort
(b) Tourniquet placed between heart and wound
(c) Tourniquet placed within 2" of wound
(2) Physiology of intervention
(a) Restriction of blood flow to and from extremity
(b) Prevent additional significant blood loss
(c) Promote localized clotting
(3) Indications
(a) Control of profuse hemorrhage
(b) Last resort after failure of other methods
i) Direct pressure
ii) Elevation
iii) Pressure dressings
iv) Pressure points
(4) Contraindications - bleeding controllable by other methods
(5) Assessment of intervention
(a) Positive control of hemorrhage
(b) Prevention of additional significant blood loss
(6) Considerations
(a) Last resort technique
(b) Used only on wounds to extremities
(c) Never apply directly to knee or elbow
(d) Once in place never loosen
i) Emboli
ii) Restart bleed
iii) Tourniquet shock
(e) Never use wire/ string/ rope

IV. Review of bandaging and dressing material used in conjunction

with soft tissue trauma

A. Dressings
    1. Sterile
        a. Has gone through process to eliminate bacteria from dressing material
        b. Used when infection is a concern
    2. Non-sterile
        a. Has not gone through process of sterilization
        b. Used when infection is not a concern
    3. Occlusive
        a. Does not allow passage of air through dressing
        b. Useful for wounds involving thorax and major vessels
            (1) Negative pressure may cause air to enter thorax or vessel
            (2) Occlusive dressing may prevent pneumothorax and air embolism
            (3) Be aware of the possibility of developing tension pneumothorax
    4. Non-occlusive
        a. Allows air to pass through dressing
        b. Useful for most standard open soft tissue injuries
    5. Adherent
        a. Dressing may adhere to wound surface by incorporating wound exudate into dressing mesh
        b. May assist in controlling acute bleeding
    6. Non-adherent
        a. Allows passage of wound exudate so that dressing will not adhere to wound surface
        b. Will not damage surface of wound when removed
        c. Used after wound closure

B. Complications of improperly applied dressings
    1. Hemodynamic
        a. Hemorrhage
        b. Exsanguination
        c. Ischemia
    2. Structural - immediate and distal
        a. Vessels
        b. Nerves
        c. Tendons
        d. Muscles
        e. Integument/ tissue
        f. Organ

3. Patient discomfort

C. Basic concepts of open wound dressing
   1. Assessment
      a. Cleansing
      b. Irrigation
      c. Debridement
      d. Definitive care as appropriate
   2. Non-adherent based dressing
      a. Function/ description
      b. Indications
      c. Contraindications
      d. Considerations
      e. Technique
         (1) Location
         (2) Application/ implementation
   3. Absorbent gauze sponges
      a. Function/ description
      b. Indications
      c. Contraindications
      d. Considerations
      e. Technique
         (1) Location
         (2) Application/ implementation
   4. Gauze wrappings
      a. Function/ description
      b. Indications
      c. Contraindications
      d. Considerations
      e. Technique
         (1) Location
         (2) Application/ implementation
   5. Taping
      a. Function/ description
      b. Indications
      c. Contraindications
      d. Considerations
      e. Technique
         (1) Location
         (2) Application/ implementation

V. Management of specific soft tissue injuries not requiring closure
   A. Dressing and bandaging specific soft tissue injuries
      1. General principles

a. Dressing application
b. Antibacterial ointment
c. Immobilization
d. Bandaging

2. Injury location
   a. Scalp dressings
   b. Facial dressings
   c. Ear or mastoid dressings
   d. Neck dressings
   e. Shoulder dressings
   f. Truncal dressings
   g. Groin, hip, and upper dressings
   h. Hand and finger dressings
   i. Elbow and knee dressings
   j. Ankle, knee, and foot dressings
3. Open wounds that should be dressed, bandaged and then transported for further evaluation
   a. Wound with neural compromise
   b. Wound with vascular compromise
   c. Wound with muscular compromise
   d. Wound with tendon/ ligament compromise
   e. Wound with heavy contamination
   f. Wound with cosmetic complications
   g. Wound with foreign body complication
4. Any other soft tissue trauma can be dressed and bandaged
   a. Consider transport versus patient discharge on-scene

B. Evaluation
1. Overview
   a. Treat and release
   b. Treat and refer
   c. Treat and transport
2. Tetanus vaccine
   a. Overview
   b. Tetanus vaccine preparation
   c. Immunization recommendations
   d. Allergic/ hypersensitive reactions
3. Patient instructions
   a. Verbal
      (1) Overview of written
      (2) Patient counseling
   b. Written

(1) Protection and care of wound area
(2) Dressing change and follow-up
(3) Wound cleansing recommendations
(4) Signs of wound infection

C. Potential and seriousness of wound infection
1. Description
a. Common complication
b. Serious complication
c. Goal
(1) Prevent from infection
(2) Protect from infection
2. Mechanism
a. Interruption in stratum corneum
b. Non sterile external environment
c. Integumentary microflora
3. Risk factors
a. Wound characteristics
b. Wound mechanism
c. Technical elements
d. General patient condition
4. Complication of wound infection
a. General patient recovery
b. Localized
c. Systemic
d. Ancillary conditions

D. Wound infection causal factors
1. Time
a. Cleansing
b. Repair
2. Mechanism
3. Location
4. Severity
a. Complications
b. Tissue damage
5. Contamination
6. Preparation
7. Cleansing
8. Technique of repair
9. General patient condition

VI. Special considerations regarding soft tissue injuries
A. Treatment priorities for patients with soft tissue injuries in conjunction with other life-threatening injuries

1. Assess for and treat any existing critical injuries to
    a. Airway
        (1) Obstructed airway
        (2) Concurrent immobilization of spine
    b. Breathing
        (1) Inadequate breathing
    c. Circulation
        (1) Hypoperfusion
        (2) Hemorrhage
2. Life-threatening injuries are managed prior to isolated soft tissue trauma
3. Institute appropriate emergency medical care for life-threat
    a. Life-threatening airway trauma
    b. Life-threatening head trauma
    c. Life-threatening thoracic trauma
    d. Life-threatening abdominal trauma

B. Emergency medical care of patients with penetrating impalations, chest, and abdominal injuries
    1. Penetrating chest injury
    2. Open wound to the abdomen
    3. Impaled object
        a. Assessment
            (1) Location
            (2) Complications
        b. Treatment
            (1) Stabilization

C. Treatment priorities for patients with amputations and avulsion
    1. Avulsion
        a. Assessment
        b. Emergency care of avulsion
            (1) Airway, ventilation, and circulation
            (2) Stabilize affected area
            (3) Dress and bandage wound appropriately
            (4) Package avulsed area, if complete avulsion, for transport
            (5) Immediate and safe transport to appropriate facility
    2. Amputations
        a. Assessment
        b. Emergency care of amputations
            (1) Airway, ventilation, and circulation

(2) Stabilize injured area
(3) Do not complete partial amputations
(4) Dress and bandage wound appropriately
(5) Package amputated body part for transport
(6) Immediate and safe transport to appropriate facility

3. Crush injuries
   a. Treatment should be started before the patient arrives in the ED
   b. Goals
      (1) Prevent sudden death
      (2) Prevent renal failure
      (3) Salvage limbs
      (4) Institute as early as possible (in the field before the patient is extricated)
      (5) ABCs as always
   c. Fluid therapy for hypovolemia
      (1) Consider bolus of 1-1.5 liters
      (2) Up to 12 liters may be needed in the first 24 hours
   d. Alkalinization of the urine
      (1) Consider adding sodium bicarbonate to IV fluid at one amp per liter to start
      (2) The goal is to maintain urine Ph > 6.5
      (3) Controls hyperkalemia and acidosis to prevent acute myoglobinuria renal failure (changes the structure of myoglobin so it passes through the renal tubules)
      (4) If done in the emergency department, irrelevant to out-of-hospital
   e. Maintain urine output
      (1) Goal of diuresis of at least 300 cc per hour
      (2) Consider Mannitol (10 g or 20% solution to each liter of IV fluid)
      (3) Loop diuretics such as Lasix are not recommended as they may acidify the urine
      (4) The “ideal fluid” for crush injury is D5 1/2 normal saline with one amp sodium bicarbonate and 10 g or 20% solution of mannitol
      (5) Treats hypovolemia
      (6) Corrects acidosis
      (7) Treats hyperkalemia, thus preventing sudden cardiac dysrhythmias

(8) Prevents renal failure

f. Further treatment of hyperkalemia
(1) Forced alkaline diuresis may be adequate
(2) CaCl is not indicated unless there is a danger of hyperkalemia dysrhythmia
(3) Consider insulin/ glucose for severe hyperkalemia (25cc D50W followed by 10 units regular insulin IV)

g. Other considerations for management - physician may come to the scene prior to extrication
(1) Amiloride
(a) K+ sparing diuretic
(b) Inhibits Na-Ca exchange - protection against "Ca++paradox"
(c) Administer before reperfusion - before crushed limb is extricated
i) Free radical scavengers
(d) Superoxide dismutase (superoxide-anion scavenger)
(2) Catalase (H_2O_2 ----> H_2O and O_2)
(3) Mannitol - scavenges hydroxyl free radicals
(4) Allopurinol (xanthine oxidase inhibitor)
(a) May prevent reperfusion induced injury in ischemic skeletal muscle and organs such as the kidneys
(b) Would have to administer before extrication or as soon as possible afterwards
(5) Hospital use of hemodialysis
(a) Role in patient who ultimately develops renal failure
(b) Can prevent permanent renal damage in patient who is not septic
(c) Prevention is the key - delays in IV fluid therapy leads to acute renal failure

4. Local injury treatment is controversial
5. Closed crush injury
a. Use of a tourniquet prior to release of crushed limb may be beneficial
b. Compartment syndrome
(1) If intracompartmental pressure > 40mm Hg or > diastolic pressure - 30 mm Hg, fasciotomy is

recommended by many if accompanied by clinical signs and symptoms
(2) Concern of increasing tissue necrosis requiring disfiguring debridement and increased risk of sepsis in those injuries older than 8 hours old
(3) Early fasciotomy can preserve limb, avoid Volkmann's contracture and preserve cutaneous sensation
(4) Medical direction may consider a field fasciotomy

6. Open crush injuries
   a. Wound care required - thorough cleansing, debridement, prophylactic antibiotics, administration of tetanus prophylaxis
   b. ED surgical consultation
7. Amputation
   a. Field - increased risk of infection/ sepsis, but may be necessary for extrication
   b. In-hospital - for severely injured limb
8. Hyperbaric oxygen treatment
   a. Shown to decrease tissue necrosis
   b. Can inhibit lipid peroxidation form oxygen free radicals (via increased levels of superoxide dismutase)
   c. Decreases muscle edema
   d. Most useful if done early

D. Documentation/ record keeping for patients with soft tissue trauma
1. Document patency of airway, ventilation, and circulation and any interventions administered
2. Document patient assessment thoroughly
3. Document general description of wound as to size, location, depth, associated complications
   a. Neurovascular status
   b. Joint injury
   c. Infection
4. Document past medical history, medications, and allergies to medications
5. Document all treatment/ interventions rendered
6. Document patient's response(s) to treatment rendered
7. Document patient's understanding of procedure

UNIT TERMINAL OBJECTIVE

4-4 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the management plan for the patient with a burn injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-4.1 Describe the anatomy and physiology pertinent to burn injuries. (C-1)
4-4.2 Describe the epidemiology, including incidence, mortality/ morbidity, risk factors, and prevention strategies for the patient with a burn injury. (C-1)
4-4.3 Describe the pathophysiologic complications and systemic complications of a burn injury. (C-1)
4-4.4 Identify and describe types of burn injuries, including a thermal burn, an inhalation burn, a chemical burn, an electrical burn, and a radiation exposure. (C-1)
4-4.5 Identify and describe the depth classifications of burn injuries, including a superficial burn, a partial-thickness burn, a full-thickness burn, and other depth classifications described by local protocol. (C-1)
4-4.6 Identify and describe methods for determining body surface area percentage of a burn injury including the "rules of nines," the "rules of palms," and other methods described by local protocol. (C-1)
4-4.7 Identify and describe the severity of a burn including a minor burn, a moderate burn, a severe burn, and other severity classifications described by local protocol. (C-1)
4-4.8 Differentiate criteria for determining the severity of a burn injury between a pediatric patient and an adult patient. (C-3)
4-4.9 Describe special considerations for a pediatric patient with a burn injury. (C-1)
4-4.10 Discuss considerations which impact management and prognosis of the burn injured patient. (C-1)
4-4.11 Discuss mechanisms of burn injuries. (C-1)
4-4.12 Discuss conditions associated with burn injuries, including trauma, blast injuries, airway compromise, respiratory compromise, and child abuse. (C-1)
4-4.13 Describe the management of a burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (C-1)
4-4.14 Describe the epidemiology of a thermal burn injury. (C-1)
4-4.15 Describe the specific anatomy and physiology pertinent to a thermal burn injury. (C-1)
4-4.16 Describe the pathophysiology of a thermal burn injury. (C-1)
4-4.17 Identify and describe the depth classifications of a thermal burn injury. (C-1)
4-4.18 Identify and describe the severity of a thermal burn injury. (C-1)
4-4.19 Describe considerations which impact management and prognosis of the patient with a thermal burn injury. (C-1)
4-4.20 Discuss mechanisms of burn injury and conditions associated with a thermal burn injury. (C-1)
4-4.21 Describe the management of a thermal burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.22 Describe the epidemiology of an inhalation burn injury. (C-1)
4-4.23 Describe the specific anatomy and physiology pertinent to an inhalation burn injury. (C-1)
4-4.24 Describe the pathophysiology of an inhalation burn injury. (C-1)
4-4.25 Differentiate between supraglottic and infraglottic inhalation injuries. (C-3)
4-4.26 Identify and describe the depth classifications of an inhalation burn injury. (C-1)

4-4.27 Identify and describe the severity of an inhalation burn injury. (C-1)
4-4.28 Describe considerations which impact management and prognosis of the patient with an inhalation burn injury. (C-1)
4-4.29 Discuss mechanisms of burn injury and conditions associated with an inhalation burn injury. (C-1)
4-4.30 Describe the management of an inhalation burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.31 Describe the epidemiology of a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.32 Describe the specific anatomy and physiology pertinent to a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.33 Describe the pathophysiology of a chemical burn injury, including types of chemicals and their burning processes and a chemical burn injury to the eye. (C-1)
4-4.34 Identify and describe the depth classifications of a chemical burn injury. (C-1)
4-4.35 Identify and describe the severity of a chemical burn injury. (C-1)
4-4.36 Describe considerations which impact management and prognosis of the patient with a chemical burn injury and a chemical burn injury to the eye. (C-1)
4-4.37 Discuss mechanisms of burn injury and conditions associated with a chemical burn injury. (C-1)
4-4.38 Describe the management of a chemical burn injury and a chemical burn injury to the eye, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.39 Describe the epidemiology of an electrical burn injury. (C-1)
4-4.40 Describe the specific anatomy and physiology pertinent to an electrical burn injury. (C-1)
4-4.41 Describe the pathophysiology of an electrical burn injury. (C-1)
4-4.42 Identify and describe the depth classifications of an electrical burn injury. (C-1)
4-4.43 Identify and describe the severity of an electrical burn injury. (C-1)
4-4.44 Describe considerations which impact management and prognosis of the patient with an electrical burn injury. (C-1)
4-4.45 Discuss mechanisms of burn injury and conditions associated with an electrical burn injury. (C-1)
4-4.46 Describe the management of an electrical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.47 Describe the epidemiology of a radiation exposure. (C-1)
4-4.48 Describe the specific anatomy and physiology pertinent to a radiation exposure. (C-1)
4-4.49 Describe the pathophysiology of a radiation exposure, including the types and characteristics of ionizing radiation. (C-1)
4-4.50 Identify and describe the depth classifications of a radiation exposure. (C-1)
4-4.51 Identify and describe the severity of a radiation exposure. (C-1)
4-4.52 Describe considerations which impact management and prognosis of the patient with a radiation exposure. (C-1)
4-4.53 Discuss mechanisms of burn injury associated with a radiation exposure. (C-1)
4-4.54 Discuss conditions associated with a radiation exposure. (C-1)
4-4.55 Describe the management of a radiation exposure, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, and psychological support/ communication strategies. (C-1)
4-4.56 Integrate pathophysiological principles to the assessment of a patient with a thermal burn injury. (C-3)
4-4.57 Integrate pathophysiological principles to the assessment of a patient with an inhalation burn injury. (C-3)

4-4.58 Integrate pathophysiological principles to the assessment of a patient with a chemical burn injury. (C-3)
4-4.59 Integrate pathophysiological principles to the assessment of a patient with an electrical burn injury. (C-3)
4-4.60 Integrate pathophysiological principles to the assessment of a patient with a radiation exposure. (C-3)
4-4.61 Synthesize patient history information and assessment findings to form a field impression for the patient with a thermal burn injury. (C-3)
4-4.62 Synthesize patient history information and assessment findings to form a field impression for the patient with an inhalation burn injury. (C-3)
4-4.63 Synthesize patient history information and assessment findings to form a field impression for the patient with a chemical burn injury. (C-3)
4-4.64 Synthesize patient history information and assessment findings to form a field impression for the patient with an electrical burn injury. (C-3)
4-4.65 Synthesize patient history information and assessment findings to form a field impression for the patient with a radiation exposure. (C-3)
4-4.66 Develop, execute and evaluate a management plan based on the field impression for the patient with a thermal burn injury. (C-3)
4-4.67 Develop, execute and evaluate a management plan based on the field impression for the patient with an inhalation burn injury. (C-3)
4-4.68 Develop, execute and evaluate a management plan based on the field impression for the patient with a chemical burn injury. (C-3)
4-4.69 Develop, execute and evaluate a management plan based on the field impression for the patient with an electrical burn injury. (C-3)
4-4.70 Develop, execute and evaluate a management plan based on the field impression for the patient with a radiation exposure. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-4.71 Value the changes of a patient's self-image associated with a burn injury. (A-2)
4-4.72 Value the impact of managing a burn injured patient. (A-2)
4-4.73 Advocate empathy for a burn injured patient. (A-2)
4-4.74 Assess safety at a burn injury incident. (A-3)
4-4.75 Characterize mortality and morbidity based on the pathophysiology and assessment findings of a patient with a burn injury. (A-3)
4-4.76 Value and defend the sense of urgency in burn injuries. (A-3)
4-4.77 Serve as a model for universal precautions and body substance isolation (BSI). (A-3)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-4.78 Take body substance isolation procedures during assessment and management of patients with a burn injury. (P-2)
4-4.79 Perform assessment of a patient with a burn injury. (P-2)
4-4.80 Perform management of a thermal burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (P-2)
4-4.81 Perform management of an inhalation burn injury, including airway and ventilation, circulation,

pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (P-2)

4-4.82 Perform management of a chemical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (P-2)

4-4.83 Perform management of an electrical burn injury, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (P-2)

4-4.84 Perform management of a radiation exposure, including airway and ventilation, circulation, pharmacological, non-pharmacological, transport considerations, psychological support/ communication strategies, and other management described by local protocol. (P-2)

DECLARATIVE

I. Introduction
  A. Epidemiology
    1. Incidence
      a. Supportive statistics
    2. Mortality/ morbidity
      a. Supportive statistics
    3. Risk factors
    4. Prevention strategies
  B. Review the anatomy and physiology of the integumentary system

II. General system pathophysiology, assessment and management
  A. Pathophysiology
    1. Pathophysiologic and systemic complications of a burn injury
      a. Fluid loss
      b. Electrolyte loss
      c. Increased catecholamine release
      d. Acidosis
      e. Vasoconstriction
      f. Renal failure
      g. Liver failure
      h. Heart failure
      i. Hypoxia
      j. Anoxia
      k. Arrhythmias
      l. Formation of eschar
      m. Hypothermia
      n. Hypovolemia
      o. Infection
      p. Complications of a circumferential burn
  B. Assessment findings
    1. Types of burn injuries
      a. Thermal burn
      b. Inhalation burn
      c. Chemical burn
      d. Electrical burn
        (1) Lightning
      e. Radiation exposure
    2. Depth classification of a burn injury
      a. Superficial burn
      b. Partial-thickness burn
      c. Full-thickness burn
      d. Other depth classifications according to local protocol
    3. Methods for determining body surface area percentage of a burn injury
      a. The "rule of nines"

(1) Adult
(2) Pediatric
b. The "rule of palms"
c. Other methods according to local protocol

4. Severity of a burn
   a. Minor burn
   b. Moderate burn
   c. Severe burn
   d. Other severity classifications according to local protocol
5. Criteria for determining severity of a burn injury
   a. The adult patient
   b. The pediatric patient
      (1) Special considerations
6. Considerations which impact management and prognosis of the burn injured patient
   a. Age
   b. Preexisting medical conditions
   c. Trauma
7. Mechanisms of burn injuries
   a. Burn trauma
   b. Blast/ explosion trauma
   c. Fall injury
   d. Other injuries
8. Conditions associated with burn injuries
   a. Trauma
      (1) Soft tissue injuries
      (2) Musculoskeletal injuries
   b. Blast injuries
   c. Airway compromise
   d. Respiratory compromise
   e. Child abuse
9. Signs and symptoms of burn injuries
   a. Pain
   b. Changes in skin condition relative to the affected burn site
   c. Adventitious sounds
   d. Sloughing of the affected skin
   e. Hoarseness
   f. Dysphagia
   g. Dysphasia
   h. Burnt hair
   i. Nausea/ vomiting
   j. Unconsciousness
   k. Altered level of consciousness
   l. Edema
   m. Paresthesia
   n. Hemorrhage
   o. Other soft tissue injuries

p. Musculoskeletal injuries
q. Dyspnea
r. Chest pain

C. Management
1. Airway, oxygenation, and ventilation
2. Circulatory management
3. Pharmacological support
a. Analgesia
4. Non-pharmacological management
5. Transport considerations
a. Appropriate mode
b. Appropriate facility
6. Psychological support/ communication strategies
a. Patient and family advocacy

III. Specific burn injuries
A. Thermal burn injury
1. Epidemiology of a thermal burn injury
a. Incidence
(1) Supportive statistics
b. Mortality/ morbidity
(1) Supportive statistics
c. Risk factors
d. Prevention strategies
2. Review the specific anatomy and physiology pertinent to the integumentary system
3. Review of heat energy and the components of the burning agent
4. Pathophysiology of a thermal burn injury
a. The process of burn shock
(1) Emergent phase
(2) Fluid shift phase
(3) Hypermetabolic phase
(4) Resolution phase
b. Jackson's thermal wound theory
(1) Zone of coagulation
(2) Zone of stasis
(3) Zone of hyperemia
c. Inhalation injury (present in 60-70% of all burn patients who die)
(1) Carbon monoxide poisoning
(2) Cyanide intoxication
d. Infectious insult
e. Eschar formation
(1) Respiratory compromise secondary to circumferential eschar around the thorax
(2) Circulatory compromise secondary to circumferential eschar around an extremity
(3) Escharotomies

5. Assessment findings in a thermal burn injury
    a. Depth classifications of a thermal burn
    b. Severity of a thermal burn
    c. Criteria for determining severity of a burn injury
        (1) The adult patient
        (2) The pediatric patient
    d. Considerations which impact care and prognosis of the thermal burn injured patient
    e. Mechanisms of burn injury
        (1) Scalding
        (2) Steam
        (3) Flame
        (4) Flash
        (5) Retained heat
        (6) Other trauma
    f. Conditions associated with thermal burn injuries
6. Management of a thermal burn injury
    a. Remove patient to safe area
    b. Stop the burning process
    c. Airway, oxygenation, and ventilation
    d. Circulatory management
    e. Pharmacological management
        (1) Topical applications
        (2) Tetanus and antibiotic therapy
        (3) Fluid therapy
    f. Non-pharmacological management
        (1) Thermal burn injury management according to local protocol
    g. Transport considerations
        (1) Appropriate mode
        (2) Appropriate facility
        (3) Transport considerations in conjunction with burn injury management according to local protocol
    h. Psychological support/ communication strategies

B. Inhalation burn injury
1. Epidemiology of an inhalation burn injury
    a. Incidence
        (1) Supportive statistics (e.g., 20-35% of the patients admitted to burn centers have an inhalation injury)
        (2) Chemical inhalation injuries are more frequent than thermal inhalation injuries
    b. Mortality/ morbidity
        (1) Supportive statistics
    c. Risk factors
        (1) Often associated with a burn environment
        (2) Factors that increase the risk for inhalation injury
            (a) Standing

(b) Screaming
(c) Enclosed area
d. Prevention strategies
2. Review the specific anatomy and physiology pertinent to the respiratory system
3. Pathophysiology of an inhalation injury
a. Compromises the upper airway (supraglottic)
b. Compromises the lower airway (infraglottic)
c. Complications may occur later
4. Assessment findings in an inhalation injury
a. Mechanism of injury/ conditions associated with an inhalation burn injury
(1) Toxic inhalations
(2) Smoke inhalation
(3) Carbon monoxide poisoning
(4) Thiocyanate intoxication
(5) Thermal burn
(6) Chemical burn
b. Criteria for determining severity of a burn injury
(1) The adult patient
(2) The pediatric patient
c. Considerations which impact care and prognosis of an inhalation burn injured patient
d. Conditions associated with inhalation burn trauma
e. Focused history
5. Management of an inhalation burn injury
a. Airway, oxygenation, and ventilation
b. Circulatory management
c. Pharmacological management
(1) Sodium thiosulfate therapy
d. Non-pharmacological management
(1) Thermal burn injury management according to local protocol
(2) Hyperbaric therapy - for carbon monoxide
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

C. Chemical burn injury
1. Epidemiology of a chemical burn injury
a. Incidence
(1) Supportive statistics
b. Mortality/ morbidity
(1) Supportive statistics
c. Risk factors
d. Prevention strategies
2. Anatomy and physiology review
3. Pathophysiology
a. Types of chemicals which cause chemical burn injuries

(1) Acids
(2) Bases (alkali)
(a) Cement
(3) Dry chemicals
(4) Phenols

b. Characteristics of the burning process of chemicals
(1) The burning process of an acid
(2) The burning process of an alkali
(3) The burning process of dry chemicals

4. Assessment of a chemical burn injury
a. Mechanism of injury/ conditions for a chemical burn injury
(1) Industrial accidents most frequent
b. Depth classification
c. Severity
d. Criteria for determining severity of a burn injury
(1) The adult patient
(2) The pediatric patient
e. Considerations which impact care and prognosis of a chemical burn injured patient

5. Management of a chemical burn injury
a. Airway, oxygen, and ventilation
b. Circulatory management
c. Pharmacological management
d. Non-pharmacological management
(1) Acid burn injury management according to local protocol
(2) Alkali burn injury management according to local protocol
(3) Chemical burn injury to the eye according to local protocol
(4) Dry chemical burn injury according to local protocol
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

D. Chemical burn injury of the eye
1. Epidemiology of a chemical burn injury
a. Incidence
(1) Supportive statistics
b. Mortality/ morbidity
(1) Supportive statistics
c. Risk factors
d. Prevention strategies
2. Anatomy and physiology review of the eye
3. Pathophysiology
a. Types of chemicals which cause chemical burn injuries to the eye
(1) Acids
(2) Bases (alkali)
(a) Cement

(3) Dry chemicals
(4) Phenols
(5) Mace/ pepper spray

4. Assessment of a chemical burn injury
   a. Mechanism of injury/ conditions for a chemical burn injury
      (1) Industrial accidents most frequent
   b. Severity
   c. Criteria for determining severity of a eye injury
   d. Considerations which impact care and prognosis of a chemical injury to the eye
5. Management of a chemical burn injury of the eye
   a. Airway, oxygenation, and ventilation
   b. Circulation management
   c. Pharmacological management
   d. Non-pharmacological management
   e. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   f. Psychological support/ communication strategies

E. Electrical burn injuries
1. Epidemiology of an electrical burn injury
   a. Incidence
      (1) Supportive statistics
   b. Mortality/ morbidity
      (1) Supportive statistics
   c. Risk factors
   d. Prevention strategies
2. Anatomy and physiology review
3. Review of the characteristics of electrical current
4. Pathophysiology
   a. External burn injuries
   b. Internal burn injuries
   c. Musculoskeletal injuries
   d. Cardiovascular injuries
   e. Respiratory injuries
   f. Neurological injuries
   g. Myoglobin release and renal involvement
5. Assessment of an electrical burn injury
   a. Mechanism of injury/ conditions for an electrical burn injury
      (1) Contact burn injuries
      (2) Arc injuries
      (3) Flame or flash burn injuries
         (a) Welder's flash
      (4) Lightning injuries
         (a) Direct stroke
         (b) Side flash (splash)
         (c) Step voltage

b. Depth classification
c. Severity
d. Criteria for determining severity of an electrical burn injury
(1) The adult patient
(2) The pediatric patient
e. Considerations which impact care and prognosis of an electrical burn injured patient

6. Management of an electrical burn injury
a. Airway, oxygenation, and ventilation
b. Circulation management
c. Pharmacological management
d. Non-pharmacological management
(1) Thermal burn injury management according to local protocol
e. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
f. Psychological support/ communication strategies

F. Radiation exposure
1. Epidemiology of a radiation exposure
a. Incidence
(1) Supportive statistics
b. Mortality/ morbidity
(1) Supportive statistics
c. Risk factors
(1) Accidents associated with the improper handling of radiological materials
d. Prevention strategies
2. Anatomy and physiology review
3. Types of radiation which cause burn injury
a. Alpha radiation
b. Beta radiation
c. Gamma radiation
4. Characteristics of ionizing radiation
a. Alpha radiation
b. Beta radiation
c. Gamma radiation
5. Aspects of exposure
a. Duration of exposure
b. Distance from the source
c. Shielding
6. Other considerations of exposure
a. Direct exposure to ionizing radiation
b. Exposure to contaminants containing small particles of active material
7. Assessment of a radiation exposure
a. Mechanism of injury
b. Depth classifications
(1) Immediate versus delayed injuries and affects

c. Severity
   (1) Immediate versus delayed injuries and affects
d. Criteria for determining severity of a radiation exposure and associated burn injury
   (1) The adult patient
   (2) The pediatric patient
e. Considerations which impact care and prognosis of a radiation exposure and burn injuries

8. Management of a radiation exposure and associated burn injuries
   a. Scene safety
   b. Airway, oxygenation, and ventilation
   c. Circulation management
   d. Pharmacological management
   e. Non-pharmacological management
      (1) Injury management according to local protocol
      (2) Management of a radiation accident scene
   f. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   g. Psychological support/ communication strategies

IV. Integration

UNIT TERMINAL OBJECTIVE

4-5 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for the trauma patient with a suspected head injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-5.1 Describe the incidence, morbidity, and mortality of facial injures. (C-1)
4-5.2 Explain facial anatomy and relate physiology to facial injuries. (C-1)
4-5.3 Predict facial injuries based on mechanism of injury. (C-1)
4-5.4 Predict other injuries commonly associated with facial injuries based on mechanism of injury. (C-2)
4-5.5 Differentiate between the following types of facial injuries, highlighting the defining characteristics of each: (C-3)
a. Eye
2. Ear
3. Nose
4. Throat
5. Mouth
4-5.6 Integrate pathophysiological principles to the assessment of a patient with a facial injury. (C-3)
4-5.7 Differentiate between facial injuries based on the assessment and history. (C-3)
4-5.8 Formulate a field impression for a patient with a facial injury based on the assessment findings. (C-3)
4-5.9 Develop a patient management plan for a patient with a facial injury based on the field impression. (C-3)
4-5.10 Explain the pathophysiology of eye injuries. (C-1)
4-5.11 Relate assessment findings associated with eye injuries to pathophysiology. (C-3)
4-5.12 Integrate pathophysiological principles to the assessment of a patient with an eye injury. (C-3)
4-5.13 Formulate a field impression for a patient with an eye injury based on the assessment findings. (C-3)
4-5.14 Develop a patient management plan for a patient with an eye injury based on the field impression. (C-3)
4-5.15 Explain the pathophysiology of ear injuries. (C-1)
4-5.16 Relate assessment findings associated with ear injuries to pathophysiology. (C-3)
4-5.17 Integrate pathophysiological principles to the assessment of a patient with an ear injury. (C-3)
4-5.18 Formulate a field impression for a patient with an ear injury based on the assessment findings. (C-3)
4-5.19 Develop a patient management plan for a patient with an ear injury based on the field impression. (C-3)
4-5.20 Explain the pathophysiology of nose injuries. (C-1)

4-5.21 Relate assessment findings associated with nose injuries to pathophysiology. (C-3)
4-5.22 Integrate pathophysiological principles to the assessment of a patient with a nose injury. (C-3)
4-5.23 Formulate a field impression for a patient with a nose injury based on the assessment findings. (C-3)
4-5.24 Develop a patient management plan for a patient with a nose injury based on the field impression. (C-3)
4-5.25 Explain the pathophysiology of throat injuries. (C-1)
4-5.26 Relate assessment findings associated with throat injuries to pathophysiology. (C-3)
4-5.27 Integrate pathophysiological principles to the assessment of a patient with a throat injury. (C-3)
4-5.28 Formulate a field impression for a patient with a throat injury based on the assessment findings. (C-3)
4-5.29 Develop a patient management plan for a patient with a throat injury based on the field impression. (C-3)
4-5.30 Explain the pathophysiology of mouth injuries. (C-1)
4-5.31 Relate assessment findings associated with mouth injuries to pathophysiology. (C-3)
4-5.32 Integrate pathophysiological principles to the assessment of a patient with a mouth injury. (C-3)
4-5.33 Formulate a field impression for a patient with a mouth injury based on the assessment findings. (C-3)
4-5.34 Develop a patient management plan for a patient with a mouth injury based on the field impression. (C-3)
4-5.35 Describe the incidence, morbidity, and mortality of head injures. (C-1)
4-5.36 Explain anatomy and relate physiology of the CNS to head injuries. (C-1)
4-5.37 Predict head injuries based on mechanism of injury. (C-2)
4-5.38 Distinguish between head injury and brain injury. (C-3)
4-5.39 Explain the pathophysiology of head/ brain injuries. (C-1)
4-5.40 Explain the concept of increasing intracranial pressure (ICP). (C-1)
4-5.41 Explain the effect of increased and decreased carbon dioxide on ICP. (C-1)
4-5.42 Define and explain the process involved with each of the levels of increasing ICP. (C-1)
4-5.43 Relate assessment findings associated with head/ brain injuries to the pathophysiologic process. (C-3)
4-5.44 Classify head injuries (mild, moderate, severe) according to assessment findings. (C-2)
4-5.45 Identify the need for rapid intervention and transport of

the patient with a head/ brain injury. (C-1)
4-5.46 Describe and explain the general management of the head/ brain injury patient, including pharmacological and non-pharmacological treatment. (C-1)
4-5.47 Analyze the relationship between carbon dioxide concentration in the blood and management of the airway in the head/ brain injured patient. (C-3)
4-5.48 Explain the pathophysiology of diffuse axonal injury. (C-1)
4-5.49 Relate assessment findings associated with concussion, moderate and severe diffuse axonal injury to pathophysiology. (C-3)
4-5.50 Develop a management plan for a patient with a moderate and severe diffuse axonal injury. (C-3)
4-5.51 Explain the pathophysiology of skull fracture. (C-1)
4-5.52 Relate assessment findings associated with skull fracture to pathophysiology. (C-3)
4-5.53 Develop a management plan for a patient with a skull fracture. (C-3)
4-5.54 Explain the pathophysiology of cerebral contusion. (C-1)
4-5.55 Relate assessment findings associated with cerebral contusion to pathophysiology. (C-3)
4-5.56 Develop a management plan for a patient with a cerebral contusion. (C-3)
4-5.57 Explain the pathophysiology of intracranial hemorrhage, including: (C-1)
a. Epidural
2. Subdural
3. Intracerebral
4. Subarachnoid
4-5.58 Relate assessment findings associated with intracranial hemorrhage to pathophysiology, including: (C-3)
a. Epidural
b. Subdural
3. Intracerebral
4. Subarachnoid
4-5.59 Develop a management plan for a patient with a intracranial hemorrhage, including: (C-1)
a. Epidural
2. Subdural
3. Intracerebral
4. Subarachnoid
4-5.60 Describe the various types of helmets and their purposes. (C-1)
4-5.61 Relate priorities of care to factors determining the need

for helmet removal in various field situations including sports related incidents. (C-3)

4-5.62 Develop a management plan for the removal of a helmet for a head injured patient. (C-3)

4-5.63 Integrate the pathophysiological principles to the assessment of a patient with head/ brain injury. (C-3)

4-5.64 Differentiate between the types of head/ brain injuries based on the assessment and history. (C-3)

4-5.65 Formulate a field impression for a patient with a head/ brain injury based on the assessment findings. (C-3)

4-5.66 Develop a patient management plan for a patient with a head/ brain injury based on the field impression. (C-3)

AFFECTIVE OBJECTIVES

None identified for this unit.

PSYCHOMOTOR OBJECTIVES

None identified for this unit.

DECLARATIVE

I. Facial Injury
  A. Introduction
    1. Incidence
    2. Morbidity and mortality
    3. Risk
  B. Review of anatomy/ physiology of the face
    1. Arteries and nerves
    2. External carotid
      a. Temporal artery
      b. Mandibular artery
      c. Maxillary artery
    3. Nerves
      a. 5th cranial nerve - trigeminal
      b. 7th cranial nerve - facial
    4. Bones
      a. Nasal
      b. Zygoma/ zygomatic arch
      c. Maxilla
      d. Mandible
  C. Common mechanisms of injury
    1. Blunt
      a. Motor vehicular crashes
      b. Falls
      c. Body-to-body contact
      d. Augmented force (i.e. sticks, clubs, etc.)
    2. Penetrating
      a. Gun shot wound, stabbing
      b. Bites - dog, human, biting tongue
  D. Other common associated injuries
    1. Airway compromise
    2. Cervical spine injury
    3. Brain injury
    4. Dental trauma or avulsion
  E. Types of facial injuries
    1. Bony injury
      a. Mandible
        (1) Fracture
        (2) Dislocation
      b. Maxillary fracture
        (1) LeFort I, II and III
      c. Zygomatic fracture
      d. Orbital fracture

(1) Eye
(2) Ear
(3) Nose
(4) Throat
(5) Mouth

e. Nasal fracture

2. Soft tissue

a. Face
b. Mouth and oropharynx and tongue
c. Ear
d. Eye

F. Assessment

1. Airway patency and adequate ventilation
2. Cervical spine integrity
3. Adequate perfusion
4. Associated injury

a. Head injury

(1) Increased ICP
(2) Presence of CSF

b. Bony injury

(1) Malocclusion
(2) Depressed zygoma
(3) Facial asymmetry
(4) Diplopia/ blurred vision

c. Soft tissue injury

(1) Open wounds
(2) Hematomas

d. Broken or missing teeth

G. History

1. Mechanism of injury
2. Events leading up to the injury
3. Time it occurred
4. Associated medical problems
5. Allergies
6. Medications
7. Last intake

H. Management

1. Airway patency and adequate ventilations a priority

a. Suctioning
b. Intubating
c. Positioning
d. Ventilating

2. Assuring adequate circulation
3. Assuring cervical spine integrity

II. Throat injuries
    A. Introduction
        1. Incidence
        2. Morbidity and mortality
        3. Risk
    B. Review of anatomy/ physiology of the throat
        1. Critical structures
            a. Airway
                (1) Oropharynx
                (2) Larynx
                (3) Trachea
            b. Cervical spine
                (1) Cord
                (2) Vertebra
            c. Major vessels
                (1) Internal and external jugular veins
                (2) Carotid arteries
                (3) Vertebral arteries
        2. Associated structures
            a. Vagus nerves
            b. Thoracic duct
            c. Pharynx and esophagus
            d. Thyroid gland and parathyroid glands
            e. Lower cranial nerves
            f. Brachial plexus - responsible for lower arm and hand function
            g. Muscles - platysma is major muscle
            h. Soft tissue and fascia
    C. Mechanism of injury
        1. Blunt - motor vehicle crashes, blow to the neck, hanging
        2. Penetrating - gun shot wound, stabbing, arrow
            a. Lacerations or puncture
    D. Pathophysiology
        1. Transected trachea
            a. Larynx separated from trachea or fractured
                (1) Vocal cord swelling or contusion
                (2) Disruption of normal airway landmarks
                (3) Associated soft tissue swelling
            b. Open wound to trachea
        2. Vessel lacerated or torn
            a. Arterial interruption
                (1) Hypoxia to brain tissue and infarct

(2) Open wound may cause an air embolism
b. Rapid exsanguination
3. Cervical spine trauma
a. Vertebral instability
b. Cord interruption
(1) Paralysis or paresthesia
(2) Neurogenic shock
4. Impaled object
a. Do not remove unless obstructing airway
b. Consider emergency cricothyrotomy

E. Assessment
1. Signs - pale or cyanotic face, bruising of neck, redness of area, hematoma in neck, with open wound will see frothy blood or sputum in wound; subcutaneous air may be present
2. Symptoms - voice changes, tickle or feeling of fullness in throat, pain on palpation
3. Signs of stroke with air emboli or infarct
4. Signs of paralysis, paresthesia or neurogenic shock if spinal cord involved
5. Assess for other injury

F. Management
1. Airway patency and adequate ventilation a priority
a. If open wound to trachea
(1) ET tube can be inserted to maintain patency
b. If closed wound
(1) BVM with oxygen supplement
(2) Consider intubation - soft tissue swelling may be extreme, aim for bubbles
(3) Consider emergency cricothyrotomy
2. Maintenance of adequate tissue perfusion
a. If open wound to neck, lay patient on left side in Trendelenburg with occlusive dressing over neck wound
b. Direct pressure to bleeding site, avoid circumferential dressings, monitor pulse for reflex bardycardia
3. Maintain cervical immobilization, avoid cervical collars or other devices that obstruct your view of the neck
4. Stabilize impaled object if not obstructing airway

III. Nasal injuries
A. Review of anatomy and physiology

1. Nasal bone - between the eyes
2. Nasal cartilage - defines shape of nose
3. Internal structures - septum, turbinates and sinuses

B. Mechanism of injury
1. Blunt - motor vehicle crashes, body-to-body contact, falls
2. Penetrating - gun shot wounds, stabbing
3. Foreign bodies - beans, crayons, anything a child can pick up

C. Pathophysiology
1. Epistaxis - nose bleeds (may compromise airway)
a. Anterior bleeds - from septum, venous bleeding
b. Posterior bleeds - often drains down back of throat
c. Associated injury
(1) Sphenoid and/ or ethmoid bone fractures
(2) Basilar skull fracture
2. Foreign bodies
a. Common in young children
b. Leave alone and transport
c. Attempt to remove only if airway is compromised

D. Assessment
1. Airway patency
2. Cervical spine precautions
3. CSF drainage
4. Associated injuries

E. Management
1. Direct pressure
2. If bleeding severe, treatment similar to hemorrhagic shock
a. Sit upright, leaning forward or lying on side so blood is not swallowed
3. If CSF detected do not apply direct pressure, let drain freely
4. Elevate head of bed in reverse Trendelenburg

IV. Ear injuries

A. Review of anatomy and physiology
1. Outer ear - Pinna
a. Cartilage
b. Poor blood supply
2. External ear canal
a. Considered a mucous membrane but secretes wax for protection

3. Middle ear
    a. Separated from external canal by ear drum
    b. Delicate structures necessary for hearing

B. Mechanism of injury
1. Blunt - motor vehicle crashes, body-to-body contact, augmented force
2. Penetrating - gun shot wound, cutting, foreign body, puncture wound
3. Blast injuries-explosions
4. Pressure injuries-diving

C. Pathophysiology
1. Ruptured ear drum
2. Basilar skull fracture
3. Separation of ear cartilage

D. Assessment
1. Adequate assessment of external ear canal and middle ear cannot be done in the field
2. Airway patency and adequate ventilation a priority
3. Maintaining adequate tissue perfusion
4. Additional injuries
    a. If mechanism warrants, cervical spine precautions

E. Management
1. Considerations
    a. Difficult for cartilage to heal
    b. Infection is prime influence for failure to heal
2. Realign ear into position and gently bandage with sufficient padding
3. Cover draining ear with loose dressing

V. Eye injuries
A. Review of anatomy and physiology
1. External parts
    a. Bony orbit
    b. Eyelids
    c. Lacrimal apparatus
2. Internal parts
    a. Sclera
    b. Cornea
    c. Conjunctiva
    d. Iris
    e. Pupil
    f. Lens
    g. Retina
    h. Optic nerve

i. Muscle control
(1) Pairs
(2) Characteristics

3. Types of vision
a. Central vision
b. Peripheral vision

B. Mechanism of injury
1. Penetrating - bullets, knives, glass, arrows, foreign bodies
2. Blunt- balls, falls, vehicle crashes, motorcycles
3. Burns- welding, sun, chemicals

C. Pathophysiology
1. Penetrating
a. Abrasions
b. Foreign bodies
(1) Superficial
(2) Deep
c. Lacerations
(1) Superficial
(2) Deep

2. Blunt
a. Swelling
b. Conjunctival hemorrhage
c. Hyphema
d. Ruptured globe
e. Blow-out fracture of orbital rim
f. Retinal detachment

3. Burns
a. Flash burns
b. Acid/ alkali

4. Other
a. Lacerated eyelid
b. Impaled object
c. Avulsion

D. Assessment
1. History
a. When did the symptoms begin
b. Mechanism of injury
c. What did the patient first notice
d. Were both eyes effected?
e. Past history
(1) Visual acuity - glasses, contacts
(2) Diseases or conditions - glaucoma, etc.
f. Any medications

2. Physical assessment
    a. Addressing priorities
        (1) Maintaining open airway and assuring adequate ventilation
        (2) Controlling bleeding and supporting cardiovascular system
        (3) Potential for central nervous system injury
    b. Orbital rim
    c. Lids
    d. Cornea
    e. Conjunctiva
    f. Eye movement
        (1) Dysconjugate gaze
        (2) Paralysis of gaze
    g. Pupils
    h. Visual acuity

E. Management
1. Blunt trauma treatment
    a. Positioning
    b. Bandaging eye(s)
        (1) One versus both
        (2) No pressure
2. Penetrating trauma treatment
    a. Positioning
    b. Removal of foreign bodies versus not
    c. Moist bandage versus dry
    d. Stabilize impaled object
3. Avulsion treatment
4. Burn
    a. Acid/ alkali
    b. Flash burn
5. Lacerated eyelid treatment

VI. Mouth injuries
A. Introduction
1. Incidence
2. Morbidity and mortality
3. Risk
B. Review of anatomy/ physiology of the mouth
1. Muscles
    a. Tongue
    b. Orbicular oris - lips
    c. Masseter muscles - cheeks
2. Nerves

a. Hypoglossal
b. Glossopharyngeal
c. Trigeminal (mandibular branch)
d. Facial

3. Bones
a. Hyoid
b. Palate
c. Mandible
d. Maxilla

4. Teeth
5. Salivary glands
6. Lymphoid tissue

C. Mechanisms of injury
1. Blunt
a. Motor vehicle crash
b. Blows to the mouth or chin
2. Penetrating
a. Gun shot wounds
b. Lacerations or punctures

D. Pathophysiology
1. Lacerated tongue
a. Airway compromise
(1) Blood and tissue
(2) Inability to communicate
b. Broken or avulsed tooth
(1) Airway compromise
c. Impaled object
(1) Airway compromise
d. Lacerated mucous membranes
(1) Copious bleeding
(2) Airway compromise
2. Assessment
a. Signs
(1) Copious bleeding
(2) Blood tinged mucous
b. Symptoms
(1) Inability to talk unless leaning forward to allow for drainage
3. Management
a. Airway patency and adequate ventilation is the first priority
b. Impaled object
(1) If patient is able to breathe - stabilize
(2) Otherwise remove

c. Collect tissue
(1) Tongue - manage as any other piece of tissue
(2) Tooth - rinse with normal saline and transport with patient

VII. Head trauma
A. Introduction
1. Incidence - approximately 4 million people sustain head injuries in the U.S. each year
2. Morbidity and mortality - approximately 450,000 require hospitalization
a. Most are minor injuries (GCS 13-15)
b. Major head injury (GCS <8) is the most common cause of death from trauma in trauma centers
c. Over 50% of all trauma deaths involve head injury
3. Risk
a. Highest in males 15-24 years of age
b. Infants 6 months to 2 years
c. Young school age children
d. The elderly
B. Review of anatomy/ physiology of head/ brain
1. Scalp
a. Hair
b. Subcutaneous tissue - contains major scalp veins which bleed profusely
c. Muscle - attached just above the eyebrows and at the base of the occiput
d. Galea - freely moveable sheet of connective tissue, helps deflect blows
e. Loose connective tissue - contains emissary veins that drain intracranially (becomes important as a route for infection)
2. Skull - divided into two main groups of bones - face and cranium
a. Cranial bones
(1) Composed of double layer of solid bone which surrounds a spongy middle layer gives greater strength
(2) Frontal, occipital, temporal, parietal, and mastoid
b. Middle meningeal artery
(1) Lies under temporal bone, if fractured can tear artery
(2) Source of epidural hematoma

c. Skull floor - many ridges
d. Foramen magnum - opening at base of skull for spinal cord

3. Brain - occupies 80% of intracranial space
   a. Divisions
      (1) Cerebrum - each lobe named after skull plates that lie immediately above
         (a) Cortex controls
            i) Voluntary skeletal movement - interference with will result in extremity paresthesia, weakness and/ or paralysis
            ii) Level of awareness - part of consciousness
         (b) Frontal lobe - personality, trauma here may result in placid reactions or seizures
         (c) Parietal lobe - somatic sensory input, memory, emotions
         (d) Temporal lobe - speech centers here, 85% of population has center on left, long term memory, taste and smell
         (e) Occipital lobe - origin of optic nerve, trauma here may cause complaints of seeing "stars", blurred vision or other visual disturbances
         (f) Hypothalamus - centers for vomiting, regulating body temperature and water
      (2) Cerebellum - coordination of voluntary movement started by cerebral cortex
      (3) Brain stem - connects the hemispheres of the brain, cerebellum and spinal cord responsible for vegetative functions and vital signs
         (a) Parts - midbrain, pons and medulla oblongata
         (b) Cranial nerves
            i) CN III - oculomotor, origin from midbrain - controls pupil size - pressure on nerve paralyzes nerve, pupil unreactive
            ii) CN X - vagal, origin from medulla - a bundle of nerves, primarily from parasympathetic system, that supply SA and AV node, stomach and

GI tract - pressure on nerve stimulates bardycardia

iii) Reticular activating system - level of arousal and responsible for specific motor movements

b. Level of consciousness
   (1) Reticular activating centers - level of arousal
   (2) Intact cortical function - level of awareness
c. Meninges - protective layers the surround and enfold entire CNS
   (1) Dura mater - outer layer, tough and fibrous; literally two layers, inner layer serves to divide and separate various brain structures, forms the tentorium that surrounds the brain stem and separates the cerebellum below from the cerebral structures above, used as a landmark to describe intracranial lesions or when swelling is involved
   (2) Arachnoid - middle layer, web-like with venous blood vessels that reabsorb cerebrospinal fluid
   (3) Pia mater - inner layer, directly attached to brain tissue, provides form
d. Cerebral spinal fluid (CSF) - clear, colorless fluid, circulates through entire brain and spinal cord
   (1) Function - cushion and protect
   (2) Ventricles - in center of brain, secretes CSF by filtering blood, forms blood-brain barrier
e. Metabolism and perfusion
   (1) High metabolic rate
   (2) Nutrients
      (a) Consumes 20% of body's oxygen
      (b) Glucose
      (c) Thiamine
      (d) Other nutrients
      (e) Nutrients cannot be stored
   (3) Blood supply
      (a) Vertebral arteries
      (b) Receives 15% cardiac output
   (4) Perfusion
      (a) Cerebral perfusion pressure (CPP)
      (b) Mechanism called autoregulation

regulates body's blood pressure to maintain CPP
(c) CPP = mean arterial pressure (MAP) - ICP
(d) MAP of at least 60 mmHg required to perfuse brain
(e) Interference with CPP - edema, bleeding, hypotension

C. Mechanisms of injury
1. Motor vehicle crashes
a. Most common cause of head trauma
b. Most common cause of subdural hematoma
2. Sports
3. Falls
a. In elderly or in presence of alcohol abuse
b. Associated with chronic subdural hematomas
4. Penetrating trauma
a. Missiles (rifles, hand guns, shotguns) more common
b. Sharp projectiles (knives, ice picks, axes and screwdrivers) not as common

D. General categories of injury
1. Coup injuries
a. Directly below point of impact
b. More common when front of head struck because of irregularity of inner surface of frontal bones; occipital area is smooth
2. Contrecoup injuries
a. On the pole opposite the site of impact
b. More common when back of head struck because of irregularity of inner surface of frontal bones
3. Diffuse axonal injury (DAI)
a. Shearing, tearing, stretching force of nerve fibers with axonal damage
b. More common with vehicular occupants and pedestrians struck by vehicle
4. Focal injury
a. An identifiable site of injury limited to a particular area or region of the brain

E. Causes of brain injury
1. Direct or primary
a. Caused by the impact
b. Mechanical disruption of cells
c. Vascular permeability
2. Indirect - secondary or tertiary
a. Secondary - caused by edema, hemorrhage, infection

and pressure inadequate perfusion (ischemia) tissue hypoxia
b. Tertiary - caused by apnea, hypotension, pulmonary resistance and change in ECG

F. Head injury - broad and inclusive
1. Defined - a traumatic insult to the head that may result in injury to soft tissue, bony structures and/ or brain injury
2. Categories - blunt (closed) trauma and open (penetrating trauma)
3. Blunt head trauma
a. More common
b. Dura remains intact
c. Brain tissue not exposed to the environment
d. May result in fractures, focal brain injuries and/ or diffuse axonal injuries (DAI)
4. Penetrating head trauma
a. Less common, gun shot wound most frequent cause
b. Dura and cranial contents penetrated
c. Brain tissue exposed to the environment
d. Results in fractures and focal brain injury

G. Brain injury
1. Defined (by National Head Injury Foundation) - "a traumatic insult to the brain capable of producing physical, intellectual, emotional, social and vocational changes"
2. Categories - focal injury, subarachnoid hemorrhage or diffuse axonal injury
a. Focal injury - specific, grossly observable brain lesions
(1) Cerebral contusion - related to severity of amount of energy transmitted
(2) Intracranial hemorrhage
(a) Penetrating
(b) Non-penetrating
(3) Epidural hemorrhage
b. Diffuse axonal injury (DAI) - effect of acceleration/ deceleration
(1) Concussion - mild and classic
(2) DAI - moderate and severe

H. Pathophysiology of head/ brain injury
1. Increased intracranial pressure (ICP)
a. Direct or indirect injury
(1) Edema

(2) Bleeding
(3) Hypotension
(4) Hypercarbia

2. Mechanism
   a. As ICP approaches MAP the gradient for flow decreases, therefore cerebral blood flow is restricted
   b. This decreases cerebral perfusion pressure (CPP)
   c. As CPP decreases, cerebral vasodilation occurs which results in increased cerebral blood volume which leads to an increase in ICP which results in a decreased CPP which leads to further cerebral vasodilation and so on
   d. Hypercarbia causes cerebral vasodilation which results in increased cerebral blood volume, which leads to increased ICP, etc.
   e. Hypotension results in decreased CPP which leads to cerebral vasodilation, etc.
3. Assessment
   a. Pressure exerted downward
      (1) Cerebral cortices and/ or reticular activating system effected
         (a) Altered level of consciousness - amnesia of event, confusion, disorientation, lethargy or combativeness, focal deficit or weakness
      (2) Hypothalamus - vomiting
      (3) Brain stem
         (a) Blood pressure elevates to maintain MAP and thus CPP
         (b) Vagal nerve pressure - bardycardia
         (c) Respiratory centers - irregular respirations or tachypnea
         (d) Oculomotor nerve paralysis - unequal/ unreactive pupils
         (e) Posturing - flexion/ extension
      (4) Seizures - depending on location of injury
   b. Levels of increasing ICP
      (1) Cerebral cortex and upper brain stem involved
         (a) BP rising and pulse rate begins slowing
         (b) Pupils still reactive
         (c) Cheyne-Stokes respirations
         (d) Initially try to localize and remove painful stimuli

i) Eventually withdraws then flexion occurs
(e) All effects reversible at this stage
(2) Middle brain stem involved
(a) Wide pulse pressure and bradycardia
(b) Pupils nonreactive or sluggish
(c) Central neurogenic hyperventilation (CNH)
(d) Extension
(e) Few patients function normally from this level
(3) Lower portion of brain stem involved/ medulla
(a) Pupil blown - same side as injury
(b) Respirations ataxic (erratic, no rhythm) or absent
(c) Flaccid
(d) Labile pulse rate, irregular often great pulse swings in rate
(e) QRS, S-T and T wave changes
(f) Decreased BP, often labile BP
(g) Not considered survivable

c. Glasgow coma scale - method to assess level of consciousness
(1) Three independent measurements
(a) Eye opening
(b) Verbal response
(c) Motor response
(2) Numerical score - 3 to 15
(3) Head injury classified according to score
(a) Mild - 13 to 15
(b) Moderate - 8 to 12
(c) Severe - < 8

d. Vital signs
e. Pupil size and reaction
f. Presence of focal deficit
g. History of unconsciousness or amnesia of event

4. Management
a. Suspect cervical spine injury
b. Airway and ventilation - oxygenate to 95% -100% saturations
(1) Oxygenation does not always require hyperventilation
(2) Hyperventilate with signs and symptoms of increased ICP

(a) Do not exceed rate of 30 - does not allow for adequate exhalation and retains carbon dioxide further contributing to hypercarbia
(3) Avoid if possible nasal intubation - increases ICP
c. Circulation - start IV of isotonic fluid (NS or LR) and titrate to BP
(1) Prevent hypotension to preserve CPP
(2) If hypotension present, look for internal bleeding
(3) Stop external bleeding
d. Disability - repeated assessment crucial to monitor presence of increased ICP, GCS and focal deficit
e. Pharmacology
(1) Osmotic diuretics
(a) Mannitol and/ or furosemide
(2) Paralytics/ sedation
(3) Avoid glucose unless hypoglycemia confirmed
f. Non-pharmacological treatment
(1) Position - head end of the backboard elevated 30 degrees
(2) Decrease CNS stimulation
g. Transport considerations
(1) Trauma center candidate - follow system guidelines
(a) Moderate to severe head injury (GCS $\leq$ 12)
(2) Use of helicopter versus ground transport
(3) Use of lights/ sirens
h. Psychological support/ communication strategies

I. Specific Injuries - diffuse axonal injury and focal injuries
1. Diffuse axonal injury - shearing, stretching or tearing of nerve fibers with subsequent axonal damage
a. Concussion (mild DAI) - physiologic neurologic dysfunction without substantial anatomic disruption which results in transient episode of neuronal dysfunction with rapid return to normal neurologic activity
(1) Epidemiology - most common result of blunt trauma to the head
(2) Assessment - confusion, disorientation, amnesia of the event

(3) Management - quiet, calm atmosphere, constant orientation and reassessment, intact airway with adequate tidal volume a priority

2. Moderate DAI - shearing, stretching or tearing results in minute petechial bruising of brain tissue, brain stem and reticular activating system may be involved leading to unconsciousness
   a. Epidemiology - occurs in 20% of all severe head injuries and 45% of all cases of DAI, commonly associated with basilar skull fracture, most survive but with neurologic impairment common
   b. Assessment - may result in immediate unconsciousness or persistent confusion, disorientation and amnesia of the event extending to amnesia of moment-to-moment events; may have focal deficit; residual cognitive (inability to concentrate), psychologic (frequent periods of anxiety, uncharacteristic mood swings) and sensorimotor deficits (sense of smell altered) may persist
   c. Management - quiet, calm atmosphere, avoid bright lights due to photophobia, constant orientation if conscious, frequent reassessment with loss of consciousness, intact airway with adequate tidal volume a priority
3. Severe DAI - formerly called brain stem injury, involves severe mechanical disruption of many axons in both cerebral hemispheres and extending to the brainstem
   a. Epidemiology - represents 16% of all severe head injuries and 36% of all cases of DAI
   b. Assessment - unconsciousness for prolonged period, posturing common, other signs of increased ICP occur depending on various degrees of damage
   c. Management
4. Focal injury
   a. Skull fracture - the significance is in the amount of force involved
      (1) Epidemiology - intact galea protects skull by deflecting force more common with augmented blunt injury, such as vehicular crashes or falls from a height
      (2) Types
         (a) Linear (80% of all skull fractures)

i) May have fluid leak out forming a bulge
ii) Fluid leak may not occur for 24 hours
iii) If no associated injuries there is no danger

(b) Depressed
i) Bone fragments protrude into brain
ii) Neurologic signs and symptoms evident

(c) Basilar
i) Extension of linear fracture to floor of skull, may not be seen on X-ray/ CT
ii) Signs and symptoms depend on amount of damage
iii) Most frequently blood vessels disrupted
a) CSF/ blood from ear(s) or nose - target sign
b) Bilateral black eyes - raccoon's sign
c) Bruising behind ear(s) - battle's sign
iv) May have seizures due to irritation of blood on brain tissue

(d) Open skull fractures
i) Severe force involved, brain tissue may be exposed
ii) Neurologic signs and symptoms evident

(3) Assessment - linear fractures may be missed, depressed and open skull fractures usually found on palpation of head, use balls of fingers to palpate
(a) Airway patency and breathing adequacy a priority
(b) Vomiting and inadequate respirations are common
(c) Assess for signs and symptoms of increased intracranial pressure
i) Altered LOC
ii) Glasgow coma scale
iii) Vomiting

iv) Pupil changes
v) Pulse, respiration and BP changes

(4) Management
(a) Cervical spine precautions
(b) Assuring clear airway and adequate ventilation with good tidal volume
(c) Hypoxia must be prevented to prevent secondary injury to brain tissue
(d) Cerebral perfusion pressure can be maintained with a systolic pressure of at least 70 mm Hg

b. Cerebral contusion - a focal brain injury in which brain tissue is bruised and damaged in a local area; may occur at both the area of direct impact (coup) and/ or on the opposite side (contrecoup) of impact

(1) Epidemiology
(a) Relatively common in blunt head injury resulting in prolonged confusion
(b) Most commonly found in frontal lobes
(c) Often associated with a serious concussion
(d) Patients may have multiple sites of contusion

(2) Assessment
(a) Airway patency and breathing adequacy a priority
(b) Alteration in level of consciousness
i) Confusion or unusual behavior common
(c) May complain of progressive headache and/ or photophobia
(d) May be unable to lay down memory - repetitive phrases common
(e) Assess for signs and symptoms of increased intracranial pressure
i) Altered LOC
ii) Glasgow coma scale
iii) Vomiting
iv) Pupil changes
v) Pulse, respiration and BP changes

(3) Management
(a) Cervical spine precautions
(b) Assuring clear airway and adequate

ventilation with good tidal volume
(c) Hypoxia must be prevented to prevent secondary injury to brain tissue
(d) Keep warm and comfortable
(e) May need to repeat information

c. Intracranial hemorrhage
(1) Types
(a) Epidural
(b) Subdural
(c) Intracerebral
(d) Subarachnoid
(2) Epidemiology
(a) Epidural hematomas almost always result from arterial tears, usually from the middle meningeal artery; they amount to about 0.5 to 1% of head injuries
(b) Subdural hematomas are more common, result from rupture of bridging veins between cortex and dura; may be acute or chronic (chronic bleeds more common in the elderly and the alcoholic)
(c) Subarachnoid hematoma results in bloody CSF and meningeal irritation
(d) Intracerebral hematoma is within the brain substance; many small, deep intracerebral hemorrhages are associated with other brain injuries (especially DAI); neurologic deficits depend on the associated injuries and the region involved, the size of the hemorrhage and whether bleeding continues
(3) Assessment
(a) May be impossible to tell which type of hematoma is present
i) History is important, what were they doing? What happened? What is wrong now? What doesn't seem right?
(b) More important to recognize the presence of brain injury
(c) Signs/ symptoms of increasing intracranial pressure
i) Headache that gets increasingly severe, vomiting, lethargy, confusion, changes in

consciousness, comatose, pupil changes, pulse slows or becomes irregular, respirations become irregular, posturing, seizures
(d) Signs/ symptoms of neurological deficit
(e) Early signs and symptoms of alterations in level of consciousness
(f) Signs of brain irritation - change in personality, irritability, lethargy, confusion, repeating words or phrases, changes in consciousness, paralysis of one side of the body, seizures
(g) GCS
(4) Management
(a) Cervical spine precautions
(b) Maintaining airway and adequate ventilation
(c) Elevating head of stretcher or backboard 30^0
(d) Establish IV, manage hypotension with fluid boluses, not to exceed a systolic of 90-100 mmHg in the adult male <40 (avoid shock)
(e) Treat increased ICP first with assuring adequate tidal volume
(f) Osmotic diuretics debatable for use by paramedics

5. Helmet issues
a. Purpose of helmet
(1) Protect head
(2) Protect the brain
(3) Cervical spine remains vulnerable
b. Various types
(1) Full face or open face (motorcycle, bicycle, roller-blade, etc.)
(2) Sports helmet (football, moto-cross, etc.)
c. Controversy regarding removal, at scene versus hospital
(1) Priorities
(a) Airway management
(b) Spinal immobilization
(2) Factors determining need for immediate removal
(a) Access to airway

(b) Patient's condition
(3) Other considerations include
(a) Ready access of athletic trainer in case of sports helmet (often have special equipment to remove face piece, allowing access to airway)
(b) Presence of other garb which could further compromise the cervical spine if only the helmet were removed (e.g. shoulder pads)
(c) Firm fit of helmet may provide firm support for head

d. Cervical spine immobilization must be done whether or not a helmet is present
e. When helmet removal occurs
(1) Requires sufficient help (stay to help in ED)
(2) Training in specific technique necessary for efficient removal
(3) Requires sufficient padding

UNIT TERMINAL OBJECTIVE

4-6 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for the patient with a suspected spinal injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-6.1 Describe the incidence, morbidity, and mortality of spinal injuries in the trauma patient. (C-1)
4-6.2 Describe the anatomy and physiology of structures related to spinal injuries. (C-1)
- a. Cervical
- b. Thoracic
- c. Lumbar
- d. Sacrum
- e. Coccyx
- f. Head
- g. Brain
- h. Spinal cord
- i. Nerve tract(s)
- j. Dermatomes

4-6.3 Predict spinal injuries based on mechanism of injury. (C-2)
4-6.4 Describe the pathophysiology of spinal injuries. (C-1)
4-6.5 Explain traumatic and non-traumatic spinal injuries. (C-1)
4-6.6 Describe the assessment findings associated with spinal injuries. (C-1)
4-6.7 Describe the management of spinal injuries. (C-1)
4-6.8 Identify the need for rapid intervention and transport of the patient with spinal injuries. (C-1)
4-6.9 Integrate the pathophysiological principles to the assessment of a patient with a spinal injury. (C-3)
4-6.10 Differentiate between spinal injuries based on the assessment and history. (C-3)
4-6.11 Formulate a field impression based on the assessment findings. (C-3)
4-6.12 Develop a patient management plan based on the field impression. (C-3)
4-6.13 Describe the pathophysiology of traumatic spinal injury related to: (C-1)
- a. Spinal shock
- b. Spinal neurogenic shock
- c. Quadriplegia/ paraplegia
- d. Incomplete cord injury/ cord syndromes:
  1. Central cord syndrome
  2. Anterior cord syndrome
  3. Brown-Sequard syndrome

4-6.14 Describe the assessment findings associated with traumatic spinal injuries. (C-1)
4-6.15 Describe the management of traumatic spinal injuries. (C-1)
4-6.16 Integrate pathophysiological principles to the assessment of a patient with a traumatic spinal injury. (C-3)
4-6.17 Differentiate between traumatic and non-traumatic spinal injuries based on the assessment and history. (C-3)
4-6.18 Formulate a field impression for traumatic spinal injury

based on the assessment findings. (C-3)
4-6.19 Develop a patient management plan for traumatic spinal injury based on the field impression. (C-3)
4-6.20 Describe the pathophysiology of non-traumatic spinal injury, including: (C-1)
a. Low back pain
b. Herniated intervertebral disk
c. Spinal cord tumors
4-6.21 Describe the assessment findings associated with non-traumatic spinal injuries. (C-1)
4-6.22 Describe the management of non-traumatic spinal injuries. (C-1)
4-6.23 Integrate pathophysiological principles to the assessment of a patient with non-traumatic spinal injury. (C-3)
4-6.24 Differentiate between traumatic and non-traumatic spinal injuries based on the assessment and history. (C-3)
4-6.25 Formulate a field impression for non-traumatic spinal injury based on the assessment findings. (C-3)
4-6.26 Develop a patient management plan for non-traumatic spinal injury based on the field impression. (C-3)

AFFECTIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-6.27 Advocate the use of a thorough assessment when determining the proper management modality for spine injuries. (A-3)
4-6.28 Value the implications of failing to properly immobilize a spine injured patient. (A-2)

PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-6.29 Demonstrate a clinical assessment to determine the proper management modality for a patient with a suspected traumatic spinal injury. (P-1)
4-6.30 Demonstrate a clinical assessment to determine the proper management modality for a patient with a suspected non-traumatic spinal injury. (P-1)
4-6.31 Demonstrate immobilization of the urgent and non-urgent patient with assessment findings of spinal injury from the following presentations: (P-1)
1. Supine
2. Prone

3. Semi-prone
4. Sitting
5. Standing

4-6.32 Demonstrate documentation of suspected spinal cord injury to include: (P-1)
a. General area of spinal cord involved
b Sensation
3. Dermatomes
4. Motor function
5. Area(s) of weakness

4-6.33 Demonstrate preferred methods for stabilization of a helmet from a potentially spine injured patient. (P-1)

4-6.34 Demonstrate helmet removal techniques. (P-1)

4-6.35 Demonstrate alternative methods for stabilization of a helmet from a potentially spine injured patient. (P-1)

4-6.36 Demonstrate documentation of assessment before spinal immobilization. (P-1)

4-6.37 Demonstrate documentation of assessment during spinal immobilization. (P-1)

4-6.38 Demonstrate documentation of assessment after spinal immobilization. (P-1)

DECLARATIVE

I. Introduction
   A. Spinal cord injury (SCI) impacts
      1. Human physiology
      2. Lifestyle
      3. Financial
      4. 1.25 million to care for a single victim with permanent SCI (overall life span)

II. Incidences
   A. 15,000 - 20,000 SCI per year
   B. Higher in men between ages 16 - 30 years
   C. Common causes
      1. Motor vehicle crashes - 2.1 million per year (48%)
      2. Falls (21%)
      3. Penetrating injuries (15%)
      4. Sports injuries (14%)

III. Morbidity and mortality
   A. 40% of trauma patients with neurological deficit will have temporary or permanent SCI
   B. 25% of SCI may be caused by improper handling
   C. Education in proper handling and transportation can decrease SCI

IV. Traditional spinal assessments/ criteria
   A. Based upon mechanism of injury (MOI)
   B. Past emphasis for spinal immobilization considerations
      1. Unconscious accident victims
      2. Conscious accident victims checked for SCI prior to movement
      3. Any patient with a “motion” injury
   C. Lack of clear clinical guidelines or specific criteria to evaluate for SCI
   D. Signs which may indicate SCI
      1. Pain
      2. Tenderness
      3. Painful movement
      4. Deformity
      5. Cuts/ bruises (over spinal area)
      6. Paralysis
      7. Paresthesias

8. Paresis (weakness)
9. Shock
10. Priapism

E. Not always practical to immobilize every “motion” injury
F. Most suspected injuries were moved to a normal anatomical position
   1. Lying flat on a spine board
   2. No exclusion criteria used for moving patients to an anatomical position
G. Need to have clear criteria to assess for the presence of SCI

V. General spinal anatomy and physiology review
   A. Spinal column
      1. Long bone
      2. 33 vertebrae
      3. Head balances at top of spine
      4. Spine supported by pelvis
      5. Ligaments and muscles connect head to pelvis
         a. Anterior longitudinal ligament
            (1) Runs on anterior portion of the body
            (2) Major source of stability
            (3) Protects against hyperextension
         b. Posterior longitudinal ligament
            (1) Runs along posterior body within the vertebral canal
            (2) Prevents hyperflexion
            (3) Can be a major source of injury
         c. Other ligaments
            (1) Cruciform ligament
            (2) Accessory atlantoaxial ligament
            (3) Add to strength, stability, and articulation
      6. Injury to ligaments may cause excess movement of vertebrae
   B. Cervical spine
      1. 7 vertebrae
      2. Supports head (16 - 25 lbs)
      3. Considered “joint above” in splinting
      4. Very flexible
      5. C1 (atlas)
      6. C2 (axis)
   C. Thoracic spine
      1. 12 vertebrae

2. Ribs connected
3. Provides rigid framework of thorax

D. Lumbar spine
1. 5 vertebrae
2. Largest vertebral body
3. Flexible
4. Carries most of body weight
5. Torso balances on sacrum

E. Sacrum
1. 5 fused vertebrae
2. Common to spine and pelvis
3. Forms “joint below” with pelvis for splinting

F. Coccyx
1. 4 fused vertebrae
2. Tailbone

G. Vertebral structure
1. Body
a. Constructed of cancellous bone
b. Posterior portion forms part of the vertebral foramen
c. Increase in size when moving from cervical to sacral region for support of the trunk

H. Vertebral foramen
1. When all vertebrae are in place forms opening for spinal cord (vertebral canal)
2. Formed by
a. Posterior portion of vertebral body
b. Pedicles
(1) Projecting posteriorly from vertebral body
c. Laminae
(1) Arise from pedicles and fuse into spinous process
(2) Failure of the laminae to unite during fetal development causes spina bifida
(a) Most commonly in the lumbosacral region

I. Transverse process
1. Runs from between the pedicles and laminae in most vertebrae
2. Projects laterally and posteriorly
3. Attachment site for various muscles and ligaments

J. Spinous process
1. Posterior aspect

2. Formed by the laminae
3. Attachment site for muscles and ligaments

K. Intervertebral foramen
1. Formed by the lower surfaces of the vertebrae
2. Creates a “notch” for spinal nerves
a. Allows nerves to connect to the spinal cord

L. Intervertebral disk
1. Mass of fibrocartilage separating each vertebrae
2. Connecting together by ligaments
3. Acts as a shock absorber
a. Reducing bone wear
b. Compression protection

M. Brain and spinal cord (central nervous system)
1. Brain
a. Largest and most complex portion of the nervous system
b. Continuous with spinal cord
c. Responsible for all sensory and motor functions
2. Spinal cord
a. Located within the vertebral canal
(1) Begins at foramen magnum
(2) Ending near L-2
b. Dural sheath
(1) Sheathed, tube-like sac
(2) Filled with cerebrospinal fluid (CSF)
3. Blood supplied by
a. Vertebral arteries
b. Spinal arteries
4. Gray matter
a. Core pattern in cord resembling butterfly with outspread wings
b. Most neurons in gray matter are interneurons
5. White matter
a. Anatomical spinal tracts
(1) Longitudinal bundles of myelinated nerve fibers
6. Ascending nerve tracts
a. Carries impulses from body parts and sensory information to the brain
b. Fasciculus gracilis and cuneatus
(1) Part of the posterior funiculi of cord
(2) Conduct sensory impulse from skin, muscle tendons, and joints to the brain for

interpretation as sensations of touch, pressure, and body movement
(3) Cross over at the medulla oblongata from one side to the other, therefore impulses originating from the left side ascend to the right side of the brain and vice versa
c. Spinothalmic tracts
(1) Lateral and anterior tracts located in the lateral and anterior funiculi
(2) Lateral tracts conduct impulses of pain and temperature to the brain
(3) Impulses cross over in the spinal cord
(4) Anterior tracts carry impulses of touch and pressure to the brain
(5) Spinocerebellar tracts (anterior and posterior) are found near the lateral funiculi and function to coordinate impulses necessary for muscular movements by carrying impulses from muscles in legs and trunk to cerebellum

7. Descending nerve tracts
a. Carries motor impulses from the brain to the body
b. Corticospinal tracts (pyramidal tracts)
(1) Lateral tract crosses over at medulla oblongata
(a) Anterior tract descend uncrossed
(b) (b) Functions to conduct motor impulses from the brain to spinal nerves and out to the body for voluntary movements
(2) Reticulospinal tracts
(a) Lateral, anterior, and medial tracts
(b) (b) Mix of crossed and uncrossed fibers
i) Some lateral fibers cross over while others do not
ii) Anterior and medial tracts remain uncrossed
(c) Motor impulses originate in the brain to control muscle tone and sweat gland activity
(3) (3) Rubrospinal tracts
(a) Fibers cross over in brain at pass through the lateral funiculi
(b) (b) Motor impulses from the brain

controlling muscle coordination and control of posture

8. Spinal nerves
   a. 31 pairs
      (1) Originates from the spinal cord
   b. Mixed nerves
      (1) Carries both sensation and motor function
      (2) Provides two-way communication between spinal cord and body parts
   c. Named according to level of spine from which they arise
      (1) Cervical 1-8
      (2) Thoracic 1-12
      (3) Lumbar 1-5
      (4) Sacral 1-5
      (5) Coccygeal 1 set of nerves
   d. Spinal nerve
      (1) Emerges from the cord
      (2) Two short branches or roots
      (3) Dorsal root
         (a) Carries sensory impulses to the cord
      (4) Ventral root
         (a) Carries motor impulses from the cord to the body
9. Motor and sensory dermatomes
   a. Dermatome is the particular area in which the spinal nerves travels or controls
   b. Mapped out by level of the spinal nerve
   c. Useful for assessment for a specific level of SCI
   d. Table for common nerve root and motor/ sensory correlation

Nerve Root	Motor	Sensory
C-3,4	Trapezius (shoulder shrug)	Top o
C-3,4,5	Diaphragm	Top of shoulder
C-5,6	Biceps (elbow flexion)	Thumb
C-7	Triceps (elbow extension)	Middle finger
	wrist/ finger extension	
C-8/ T-1	Finger abduction/ adduction	

		Little finger
T-4	Nipple	
T-10	Umbilicus	
L-1,2	Hip flexion	
		Inguinal crease
L-3,4	Quadriceps	
		Medial thigh/ calf
L-5	Great toe/ foot dorsiflexion	
		Lateral calf
S-1	Knee flexion	Lateral foot
S-1,2	Foot plantar flexion	
S-2,3,4	Anal sphincter tone	
		Perianal

VI. General assessment of spinal injuries
    A. Determine mechanism of injury/ nature or injury
        1. Positive MOI
            a. Always requires full spinal immobilization
                (1) High speed motor vehicle crash(es)
                (2) Falls greater than three times patient's height
                (3) Violent situations occurring near the spine
                    (a) Stabbings
                    (b) Gun shots
                    (c) Others
                (4) Sports injuries
                (5) Other high impact situations
            b. Some medical directors may allow field personnel to not immobilize patients with MOI but without signs and/ or symptoms of a SCI
                (1) Based on assessment
                    (a) Patient reliability
                    (b) No distracting injuries
                    (c) Lack of signs or symptoms
        2. Negative MOI
            a. Forces or impact involved does not suggest a potential spinal injury
            b. Does not require spinal immobilization

(1) Examples
(a) Dropping a rock on foot
(b) Twisted ankle while running
(c) Isolated soft tissue injury

3. Uncertain MOI
a. Unclear or uncertainty regarding the impact or forces
b. Clinical criteria used for a basis of whether to employ spinal immobilization
(1) Examples
(a) Person trips over garden hose, falling to the ground and hitting their head
(b) Fall from 2-4 feet
(c) Low speed motor vehicle crash (fender bender)

4. Clinical criteria versus mechanism of injury
a. Initial management
(1) Based solely upon MOI
b. Positive MOI
(1) Spine immobilization
c. Negative MOI
(1) Without signs or symptoms
(a) No spine immobilization
d. Uncertain MOI
(1) Need for further clinical assessment and evaluation
e. In some non-traumatic spinal conditions immobilization may be necessary/ indicated
f. Altered LOC or unconsciousness requires spine stabilization

VII. Assessment of uncertain MOIs
A. Specific clinical criteria
1. Necessary to assess when electing not to immobilize a trauma patient
2. Begins with patient reliability
a. Continually reassessed during specific exam
3. If specific criteria cannot be clearly satisfied; complete spine immobilization undertaken
4. Positive MOI always equals spine immobilization
a. This specific assessment may still be used to determine level of injury
B. Specific criteria

1. Prevent motion of the spine by assistant maintaining stabilization throughout the exam
2. Reliable patients/ exam
    a. In order for assessments of pain, tenderness, motor, and sensory function to be accurate the patient must be reliable
    b. Patient must be
        (1) Calm
        (2) Cooperative
        (3) Sober
            (a) Alcohol
            (b) Drugs
        (4) Alert and oriented
    c. Unreliable patient defined
        (1) Acute stress reaction
            (a) Sudden stress of any type
        (2) Brain injury
            (a) Any temporary change in consciousness or altered level of consciousness
            (b) Uncooperative or belligerent behavior
        (3) Intoxication
        (4) Abnormal mental status
        (5) Distracting injuries
        (6) Communication problems
    d. Unreliable indicators present
        (1) Full spinal immobilization indicated
3. Assess for spinal pain
    a. Patient is asked about
        (1) Any related spinal pain
        (2) Signs
        (3) Symptoms
    b. May be poorly localized
    c. Might not feel directly over the spinous process
    d. Pain with active movement of head and neck
        (1) Patient is asked to slowly move their head and neck
        (2) If any pain occurs
            i) Full immobilization is indicated
            ii) May not be able to splint in normal anatomical position
4. Assess for spine tenderness
    a. Palpate over each of the spinous processes of the vertebra

b. Begin at the neck and work towards the pelvis
c. May be beneficial to palpate back up from the pelvis to the neck

5. Upper extremity neurological function assessment
   a. Motor function
      (1) Finger abduction/ adduction
         (a) Test interosseous muscle function controlled by T-1 nerve roots
         (b) Have patient spread fingers of both hands and keep them apart while you squeeze the 2nd and 4th fingers
         (c) Normal resistance should be spring-like and equal on both sides
      (2) Finger/ hand extension
         (a) Test the extensors of the hand and fingers controlled by C-7 nerve roots
         (b) Have patient hold wrist or fingers straight out and keep them out while you press down on their fingers
         (c) Support the arm at the wrist to avoid testing arm function and other nerve roots
         (d) Normal resistance should be felt to moderate pressure
         (e) Both right and left sides should be checked
         (f) Can still check if isolated, e.g., finger fracture, push on hand only not fingers; if wrist injury support MP joints and push on fingers only
   b. Sensory function
      (1) Pain sensation
         (a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain
         (b) Pain or pinprick controlled by spinothalamic tracts
         (c) Need to separate from light touch (remember light touch carried by more than one tract)
         (d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)

(e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain
(f) Compare on both sides of the body; equal on both sides

6. Lower extremity neurological function assessment
   a. Motor function
      (1) Foot plantar flexion
         (a) Tests plantar flexors of the foot controlled by S-1,2 nerve root
         (b) Place your hands at the sole of each foot and have the patient push against your hands
         (c) Both sides should feel equal and strong
      (2) Foot/ great toe dorsiflexion
         (a) Tests the dorsal flexors of the foot and great toe controlled by the L-5 nerve roots
         (b) Hold foot with fingers on toes and instruct patient to pull foot back or towards their nose
   b. Sensory function
      (1) Pain sensation
         (a) Abnormal sensation - ask patient about weakness, numbness, paresthesia, or radicular pain
         (b) Pain or pinprick controlled by spinothalamic tracts
         (c) Need to separate from light touch (remember light touch carried by more than one tract)
         (d) Use end of pen or broken Q-tip (avoid sharp objects which may damage or cause bleeding)
         (e) Have patient close eyes and hold out hands; ask the patient to compare between sharp and dull pain
         (f) Compare on both sides of the body; equal on both sides
7. General motor function assessment
   a. Tests nerve roots at both cervical and lumbar/ sacral spine levels
   b. Check two sets of nerve roots at each level as

well as left and right sides
c. Able to determine most clinical patterns of SCI
d. Motor exams can to be completed even if local injury exists
(1) If exam cannot be completed due to local injury entire exam is unreliable
(a) Spinal immobilization indicated

8. Sensory function assessment
a. Test (exam) sensory
(1) At cervical and lumbar/ sacral spine levels
(a) On both right and left sides
b. Sensory exam will detect clinical patterns of SCI
c. Any signs or symptoms of abnormal sensation
(1) Spinal immobilization indicated

VIII. General management of spinal injuries
A. Principles of spinal immobilization
1. Primary goal is to prevent further injury
2. Treat spine as a long bone with a joint at either end (head and pelvis)
3. 15% of secondary spinal injuries are preventable with proper immobilization
4. Always use “complete” spine immobilization
a. Impossible to isolate and splint specific injury site
5. Spine stabilization begins in the initial assessment
a. Continues until the spine is completely immobilized on a long backboard
6. Head and neck should be placed in a neutral, in-line position unless contraindicated
a. Neutral positioning allows for the most space for the cord
(1) Reducing cord hypoxia
(2) Reducing excess pressure
b. Most stable position for the spinal column
(1) Reduces instability
B. Spinal stabilization/ immobilization
1. Systematic approach
a. Cervical immobilization
(1) Manual
(2) Rigid collar
b. Interim immobilization device
(1) When indicated (vest type mobilization

device, short backboard)
(2) Movement of a stable patient from a seated position to a long backboard

c. Long backboard
d. Full body vacuum splints
e. Padding (body shims)
(1) Use to maintain anatomical position
(2) Limits movement of patient
(3) Fill all voids
(4) Pillows
(5) Towels
(6) Blankets
f. Straps
(1) Sufficient to immobilize to the long backboard
(a) Upper torso
(b) Pelvis
(c) Legs
(d) Feet
g. Cervical immobilization device
(1) Commercial
(2) Tape
(3) Blanket roll
(4) Pillows
h. Helmeted patients
(1) Special assessment needs for patients wearing helmets
(a) Airway and breathing
(b) Fit of helmet and movement within the helmet
(c) Ability to gain access to airway and breathing
(2) Indications for leaving the helmet in place
(a) Good fit with little or no head movement within helmet
(b) No impending airway or breathing problems
(c) Removal may cause further injury
(d) Proper spinal immobilization could be performed with helmet in place
(e) No interference with ability to assess and reassess airway
(3) Indications for helmet removal

(a) Inability to assess or reassess airway and breathing
(b) Restriction of adequate management of the airway or breathing
(c) Improperly fitted helmet with excessive head movement within helmet
(d) Proper spinal immobilization cannot be performed with helmet in place
(e) Cardiac arrest

(4) Types of helmets
(a) Sports
i) Typically worn anteriorly
ii) Easier access to airway
(b) Motorcycle
i) Full face
ii) Shield
(c) Other

(5) General guidelines for helmet removal
(a) Type of helmet worn by the patient will influence the technique used for removal
(b) First person stabilizes the head and neck by placing hands on the side of the helmet with fingers extended under lower face piece (or chin)
(c) Second person removes face shield (if present) and/or eye wear before helmet removal
(d) Second person removes chin strap
(e) Second person places one hand on mandible and the other posteriorly on the occipital region (posterior caudal edge of helmet)
(f) First person then begins to remove the helmet by pulling the sides apart, sliding the helmet a short distance (approximately 4-6 cm) and then stops
(g) First person again stabilizes the head and neck with hands holding the sides of the helmet
(h) Second person slides hands cephalad (towards the top of the head) until the head is stabilized between the posterior or hand (now cupped under the inferior

occiput) and the anterior hand now inserted under the lower part of the face piece - if the helmet has one (thumb and first finger now holding the unmovable maxilla)

(i) First person again pulls the sides of the helmet apart and continues to withdraw the helmet - rotating the helmet as necessary so any lower face piece clears the nose and then an opposite movement so the posterior caudal end of the helmet is removed following the posterior curvature of the patient's head

(j) Once the helmet has been completely removed, the first person regains stabilization of the patient's head and neck by placing their hands along the sides of the patient's head with their fingers spread apart for maximum support - second person can now let go of the anterior/posterior support

(k) Second person can now continue with the assessment, measurement and application of a cervical collar, further immobilization and care of the patient

C. Use of steroids for traumatic spine injuries

IX. Traumatic injuries
- A. Causes
  - 1. Direct trauma
  - 2. Excessive movement
    - a. Acceleration
    - b. Deceleration
    - c. Deformation
  - 3. Directions of force
    - a. Flexion or hyperflexion
      - (1) Excessive forward motion of the head

(2) May cause
(a) Wedge fracture of anterior vertebrae
(b) Stretching or rupturing of interspinous ligaments
(c) Compressed injury to spinal cord
(d) Disruption of disk with forward dislocation of vertebrae
(e) Fracture of pedicle and disruption of interspinous ligament
(3) Cervical area common injury site

b. Extension or hyperextension
(1) Excessive backward movement of the head
(2) May cause
(a) Disruption of the intervertebral disks
(b) Osteophytes and compression of the spinal cord
(c) Compression of the interspinous ligament
(d) Fracture
(3) Cervical area common injury site

c. Rotational
(1) Usually from acceleration forces
(2) May cause
(a) Flexion-rotation dislocation
(b) Fracture or dislocation of vertebrae
(c) Rupture of supporting ligaments
(3) Cervical area common injury site

d. Lateral bending
(1) Often caused by direct blow to the side of the body
(2) May cause
(a) May cause lateral compression of the vertebral body
(b) may cause lateral displacement of the vertebra
(c) May stretch the ligaments

e. Vertical compression
(1) Force applied along spinal axis
(a) Usually from top of cranium to vertebral body from sudden deceleration, e.g., diving accident
(2) May cause
(a) Compression fracture without SCI
(b) Crushed vertebral body with SCI

(3) Most common injury site(s)
(a) T-12 to L-2
f. Distraction
(1) Force applied to spinal axis to distract or pull apart, e.g., hanging injury
(2) May cause
(a) Stretching of spinal cord
(b) Stretching of supporting ligaments
(3) Cervical area most common injury site
4. Can have “spinal column injury” (bony injury) with or without “SCI”
5. Can have “SCI” with or without “spinal injury”

B. Types of spinal cord injuries (SCI)
1. Primary injury
a. Occurs at time of impact/ injury
b. Causes
(1) Cord compression
(2) Direct cord injury
(a) Sharp or unstable bony structures
(3) Interruption in the cord’s blood supply
2. Secondary injury
a. Occurs after initial injury
b. Causes
(1) Swelling
(2) Ischemia
(3) Movement of bony fragments
3. Cord concussion
a. Results from temporary disruption of cord-mediated functions
4. Cord contusion
a. Bruising of the cord’s tissues
b. Causes
(1) Swelling
c. Temporary loss of cord-mediated function
5. Cord compression
a. Pressure on the cord
b. Causes tissue ischemia
c. Must be decompressed to avoid permanent loss/ damage to cord
6. Laceration
a. Tearing of the cord tissue
b. May be reversed if only slight damage
c. May result in permanent loss if spinal tracts are

disrupted

7. Hemorrhage
   a. Bleeding into the cord's tissue
   b. Caused by damage to blood vessels
      (1) Injury related to amount of hemorrhage
   c. Damage or obstruction to spinal blood supply results in local ischemia
8. Cord transection
   a. Complete
      (1) All tracts of the spinal cord completely disrupted
      (2) Cord-mediated functions below transection are permanently lost
      (3) Accurately determined after at least 24 hours post-injury
      (4) Results in
         (a) Quadriplegia
            i) Injury at the cervical level
            ii) Loss of all function below injury site
         (b) Paraplegia
            i) Injury at the thoracic or lumbar level
            ii) Loss of lower trunk only
   b. Incomplete
      (1) Some tracts of the spinal cord remain intact
      (2) Some cord-mediated functions intact
      (3) Has potential for recovery
         (a) Function may only be temporarily lost
      (4) Types
         (a) Anterior cord syndrome
            i) Caused by bony fragments or pressure on spinal arteries
            ii) Involves loss of motor function and sensation to pain, temperature and light touch
            iii) Sensation to light touch, motion, position, and vibration are spared
         (b) Central cord syndrome
            i) Usually occurs with a hyperextension of the cervical region
            ii) Weakness or paresthesias in upper

extremities but normal strength in lower extremities
iii) May have varying degrees of bladder dysfunction
(c) Brown-Sequard syndrome
i) Caused by penetrating injury
ii) Hemisection of the cord
iii) Involves only one side of the cord
iv) Complete damage to all spinal tract on involved side
v) Isolated loss of all types of functions, e.g., motor pain, temperature, motion, position, etc.
vi) Pain and temperature lost on opposite side of the body
vii) Motor function, motion, position, vibration, and light touch on the same side as injury

9. Chemical and metabolic changes due to SCI
10. Spinal shock
    a. Refers to temporary loss of all types of spinal cord function distal to injury
    b. Flaccid paralysis distal to injury site
    c. Loss of autonomic function
        (1) Hypotension
        (2) Vasodilatation
        (3) Loss of bladder and bowel control
        (4) Priapism
        (5) Loss of thermoregulation
    d. Does not always involve permanent primary injury
        (1) Usually will resolve in a period of hours to weeks
        (2) Manage carefully to avoid secondary injury
11. Spinal neurogenic shock
    a. Also called spinal vascular shock
    b. Temporary loss of the autonomic function of the cord at the level of injury which
    c. Presentation includes
        (1) Loss of sympathetic tone
        (2) Relative hypotension
            (a) Systolic pressure 80 - 100 mmHg
        (3) Skin pink, warm and dry
            (a) Due to cutaneous vasodilation

(4) Relative bradycardia
d. Rare in occurrence
e. Shock presentation is usually the result of hidden volume loss
(1) Chest injuries
(2) Abdominal injuries
(3) Other violent injuries
f. Treatment
(1) Focus primarily on volume replacement
12. Autonomic hyperreflexia syndrome
a. Associated after resolution of spinal shock
(1) Chronic SCI patients
b. Massive, uncompensated cardiovascular response
(1) Stimulation of the sympathetic nervous system
c. Life-threatening condition usually seen with injuries at T-6 or above
d. Characteristics are
(1) Paroxysmal hypertension (up to 300 mmHg systolic)
(2) Headache (pounding)
(3) Blurred vision
(4) Sweating
(a) Above level of injury with flushing of the skin
(5) Increased nasal congestion
(6) Nausea
(7) Bradycardia
(8) Associate distended bladder or rectum
e. Stimulation of the sensory receptors below the level of the cord injury
(1) Autonomic nervous system reflexively responds with arteriolar spasm
(a) Increases blood pressure
(2) Cerebral, carotid, and aorta baroreceptors sense hypertension
(a) Stimulates the parasympathetic nervous system
(b) Heart rate decreases
(c) Peripheral and visceral vessels unable to dilate due to cord damage
(3) May be treated with an antihypertensive medication

X. Non-traumatic spinal conditions
  A. Low back pain (LBP)
    1. Affected area
      a. Between lower rib cage and gluteal muscles
      b. May radiate to thighs
    2. 1% of acute low back pain is sciatica
      a. Usual cause is in the lumbar nerve root
      b. Pain accompanied by motor and sensory deficits, e.g., weakness
    3. 60% - 90% of population experience some form of low back pain
      a. Affects men and women equally
      b. Women over 60 years old report low back pain symptoms more often
    4. Most cases of LBP are idiopathic
      a. Precise diagnosis difficult
    5. Causes
      a. Tension from tumors
      b. Disk prolapsed
      c. Bursitis
      d. Synovitis
      e. Rising venous pressure
      f. Tissue pressure due to degenerative joint disease
      g. Abnormal bone pressure
      h. Problems with spinal mobility
      i. Inflammation caused by infection
        (1) Osteomyelitis
      j. Fractures
      k. Ligament strains
    6. Risk factors
      a. Occupations requiring repetitious lifting
      b. Exposure to vibrations from vehicles or industrial machinery
      c. Osteoporosis
    7. Anatomical considerations
      a. Pain from innervated structures
        (1) Varies from person-to-person
      b. Disk has no specific innervation
        (1) Compresses cord if herniated
      c. Source of pain in L-3,4,5, and S-1 may be interspinous bursae
      d. Anterior and posterior longitudinal ligaments, and other ligaments are richly

supplied with pain receptors
e. Muscles of spine vulnerable to sprains/ strains
8. Degenerative disk disease
a. Common for patients over 50 years of age
b. Causes
(1) Degeneration of disk
(a) Biomechemical alterations of intervertebral disk
c. Narrowing of the disk
(1) Results in variable segment stability
9. Spondylolysis
a. Structural defect of spine
(1) Involves the lamina or vertebral arch
b. Usually occurs between superior and inferior articulating facets
c. Heredity a significant factor
d. Rotational fractures common at affected site
10. Herniated intervertebral disk
a. Also called herniated nucleus pulposus
b. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
c. Causes
(1) Trauma
(2) Degenerative disk disease
(3) Improper lifting
(a) Most common cause
d. Men ages 30 - 50 years are more prone than women
e. Commonly affects L-5, S-1 and L-4, L-5 disks
f. May also occur in C-5, C-6, and C-7
11. Spinal cord tumors
a. Causes
(1) Compression of the cord
(2) Degenerative changes in the bone/ joints
(3) Interrupted the blood supply
b. Manifestations are dependent upon
(1) Tumor type and location

XI. Assessment and management of non-traumatic spinal conditions
A. Assessment - based mainly upon the patient's chief complaint and physical exam
1. Low back pain
a. Based mainly upon history and chief complaint
(1) Risk factors include

(a) Occupations requiring repetitive lifting
(b) Exposure to vibrations from vehicles or industrial machinery
(c) Osteoporosis

b. Precise diagnosis difficult
(1) Based primarily on physical exam and other in-hospital testing
(a) CT scan
(b) Electromyelography
(c) MRI
(d) Others

2. Herniated intervertebral disk
a. Tear in the posterior rim of capsule enclosing the gelatinous center of the disk
(1) Causes
(a) Trauma
(b) Degenerative disk disease
(c) Improper lifting
i) Most common cause
(2) Pain usually occurs with straining
(a) Coughing or sneezing
(3) May have limited range of motion in lumbar spine
(4) Tenderness upon palpation
(5) Alternations in sensation, pain, and temperature
(6) Due to nerve root pressure
(7) Cervical herniations may include
(a) Upper extremity pain or paresthesia
i) Increasing with neck motion
(b) Slight motor weakness may also occur in biceps and triceps

3. Spinal cord tumors
a. Tumors of the spine which cause
(1) Compression of the cord
(2) Degenerative changes in the bone/ joints
(3) Interruption in the blood supply
b. Manifestations are dependent upon
(1) Tumor type
(2) Location

B. Management
1. Primarily palliative to decrease any pain or discomfort from movement

2. May elect to immobilize to aid in comfort
   a. Long back board
   b. Vacuum type stretcher
3. Full spinal immobilization is not required unless condition is a result of trauma

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UNIT TERMINAL OBJECTIVE

4-7 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement a treatment plan for a patient with a thoracic injury.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-7.1 Describe the incidence, morbidity, and mortality of thoracic injuries in the trauma patient. (C-1)
4-7.2 Discuss the anatomy and physiology of the organs and structures related to thoracic injuries. (C-1)
4-7.3 Predict thoracic injuries based on mechanism of injury. (C-2)
4-7.4 Discuss the types of thoracic injuries. (C-1)
4-7.5 Discuss the pathophysiology of thoracic injuries. (C-1)
4-7.6 Discuss the assessment findings associated with thoracic injuries. (C-1)
4-7.7 Discuss the management of thoracic injuries. (C-1)
4-7.8 Identify the need for rapid intervention and transport of the patient with thoracic injuries. (C-1)
4-7.9 Discuss the pathophysiology of specific chest wall injuries, including: (C-1)
- a. Rib fracture
- 2. Flail segment
- 3. Sternal fracture

4-7.10 Discuss the assessment findings associated with chest wall injuries. (C-1)
4-7.11 Identify the need for rapid intervention and transport of the patient with chest wall injuries. (C-1)
4-7.12 Discuss the management of chest wall injuries. (C-1)
4-7.13 Discuss the pathophysiology of injury to the lung, including: (C-1)
- 1. Simple pneumothorax
- 2. Open pneumothorax
- 3. Tension pneumothorax
- 4. Hemothorax
- 5. Hemopneumothorax
- 6. Pulmonary contusion

4-7.14 Discuss the assessment findings associated with lung injuries. (C-1)
4-7.15 Discuss the management of lung injuries. (C-1)
4-7.16 Identify the need for rapid intervention and transport of the patient with lung injuries. (C-1)
4-7.17 Discuss the pathophysiology of myocardial injuries, including: (C-1)
- a. Pericardial tamponade
- 2. Myocardial contusion
- 3. Myocardial rupture

4-7.18 Discuss the assessment findings associated with myocardial injuries. (C-1)
4-7.19 Discuss the management of myocardial injuries. (C-1)
4-7.20 Identify the need for rapid intervention and transport of the patient with myocardial injuries. (C-1)
4-7.21 Discuss the pathophysiology of vascular injuries, including injuries to: (C-1)

a. Aorta
2. Vena cava
3. Pulmonary arteries/ veins

4-7.22 Discuss the assessment findings associated with vascular injuries. (C-1)
4-7.23 Discuss the management of vascular injuries. (C-1)
4-7.24 Identify the need for rapid intervention and transport of the patient with vascular injuries. (C-1)
4-7.25 Discuss the pathophysiology of diaphragmatic injuries. (C-1)
4-7.26 Discuss the assessment findings associated with diaphragmatic injuries. (C-1)
4-7.27 Discuss the management of diaphragmatic injuries. (C-1)
4-7.28 Identify the need for rapid intervention and transport of the patient with diaphragmatic injuries. (C-1)
4-7.29 Discuss the pathophysiology of esophageal injuries. (C-1)
4-7.30 Discuss the assessment findings associated with esophageal injuries. (C-1)
4-7.31 Discuss the management of esophageal injuries. (C-1)
4-7.32 Identify the need for rapid intervention and transport of the patient with esophageal injuries. (C-1)
4-7.33 Discuss the pathophysiology of tracheo-bronchial injuries. (C-1)
4-7.34 Discuss the assessment findings associated with tracheo-bronchial injuries. (C-1)
4-7.35 Discuss the management of tracheo-bronchial injuries. (C-1)
4-7.36 Identify the need for rapid intervention and transport of the patient with tracheo-bronchial injuries. (C-1)
4-7.37 Discuss the pathophysiology of traumatic asphyxia. (C-1)
4-7.38 Discuss the assessment findings associated with traumatic asphyxia. (C-1)
4-7.39 Discuss the management of traumatic asphyxia. (C-1)
4-7.40 Identify the need for rapid intervention and transport of the patient with traumatic asphyxia. (C-1)
4-7.41 Integrate the pathophysiological principles to the assessment of a patient with thoracic injury. (C-1)
4-7.42 Differentiate between thoracic injuries based on the assessment and history. (C-3)
4-7.43 Formulate a field impression based on the assessment findings. (C-3)
4-7.44 Develop a patient management plan based on the field impression. (C-3)

AFFECTIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-7.45 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for thoracic trauma. (A-3)
4-7.46 Advocate the use of a thorough scene survey to determine the forces involved in thoracic trauma. (A-3)

4-7.47 Value the implications of failing to properly diagnose thoracic trauma. (A-2)
4-7.48 Value the implications of failing to initiate timely interventions to patients with thoracic trauma. (A-2)

PSYCHOMOTOR OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-7.49 Demonstrate a clinical assessment for a patient with suspected thoracic trauma. (P-1)
4-7.50 Demonstrate the following techniques of management for thoracic injuries: (P-1)
- a. Needle decompression
- 2. Fracture stabilization
- 3. Elective intubation
- 4. ECG monitoring
- 5. Oxygenation and ventilation

DECLARATIVE

I. Introduction
- A. Epidemiology
  - 1. Incidence
  - 2. Morbidity and mortality of thoracic injuries
  - 3. Risk factors
  - 4. Prevention strategies
    - a. Gun safety education
    - b. Sports training
    - c. Seat belts
    - d. Other
- B. Mechanism of injury
  - 1. Classification
    - a. Blunt thoracic injuries
      - (1) Deceleration
      - (2) Compression
    - b. Penetrating thoracic injuries
  - 2. Injury patterns
    - a. General Types
      - (1) Open injuries
      - (2) Closed Injuries
    - b. Thoracic cage
    - c. Cardiovascular
    - d. Pleural and pulmonary
    - e. Mediastinal
    - f. Diaphragmatic
    - g. Esophageal
    - h. Penetrating cardiac trauma
  - 3. Blast injury
    - a. Confined spaces
    - b. Shock wave
- C. Anatomy and physiology review of the thorax
  - 1. Anatomy
    - a. Skin
    - b. Bones
      - (1) Thoracic cage
      - (2) Sternum
      - (3) Thoracic spine
    - c. Muscles
      - (1) Intercostal
      - (2) Trapezius
      - (3) Latisissimus dorsi

(4) Rhomboids
(5) Pectoralis major
(6) Diaphragm
(7) Sternocleidomastoid

d. Trachea
e. Bronchi
f. Lungs
(1) Parenchyma
(2) Alveoli
(3) Alveolar - capillary interface
(4) Pleura
(a) Visceral
(b) Parietal
(c) Serous fluid
(5) Lobes

g. Vessels
(1) Arteries
(a) Aorta
(b) Carotid
(c) Subclavian
(d) Intercostal arteries
(e) Innominate
(f) Internal mammary
(2) Veins
(a) Superior vena cava
(b) Inferior vena cava
(c) Subclavian
(d) Internal jugular
(3) Pulmonary
(a) Arteries
(b) Veins

h. Heart
(1) Ventricles
(2) Atria
(3) Valves
(4) Pericardium

i. Esophagus
(1) Thoracic inlet
(2) Course through chest
(3) Esophageal foramen through diaphragm

j. Mediastinum
(1) Structures located in mediastinum
(a) Heart
(b) Trachea
(c) Vena cava
(d) Aorta
(e) Esophagus

2. Physiology

a. Ventilation
(1) Expansion and contraction of thoracic cage
(a) Bellows system
(b) Musculoskeletal structure
(c) Intercostal muscles
(d) Diaphragm
(e) Accessory muscles
(f) Changes in intrathoracic pressure
b. Respiration
(1) Neurochemical control
(2) Gas exchange
(a) Alveolar-capillary interface
(b) Capillary-cellular interface
(c) Pulmonary circulation
(d) Cardiac circulation
(e) Acid-base balance
i) Henderson-Hasselbach equation
ii) Respiratory alkalosis
iii) Respiratory acidosis
iv) Compensation for metabolic acidosis and alkalosis

II. General system pathophysiology, assessment and management of thoracic trauma
A. Pathophysiology
1. Impairments in cardiac output
a. Blood loss
b. Increased intrapleural pressures
c. Blood in pericardial sac
d. Myocardial valve damage
e. Vascular disruption
2. Impairments in ventilatory efficiency
a. Chest bellow action compromise
(1) Pain restricting chest excursion
(2) Air entering pleural space
(3) Chest wall fails to move in unison
b. Bleeding in pleural space
c. Ineffective diaphragmatic contraction
3. Impairments in gas exchange
a. Atelectasis
b. Contused lung tissue
c. Disruption of respiratory tract
B. Assessment findings
1. Pulse
a. Deficit
b. Tachycardia
c. Bradycardia
2. Blood pressure
a. Narrow pulse pressure
b. Hypertension

- c. Hypotension
- d. Pulsus paradoxus

3. Respiratory rate and effort
   - a. Tachypnea
   - b. Bradypnea
   - c. Labored
   - d. Retractions
   - e. Other evidence of respiratory distress
4. Possible hypothermia
5. Skin
   - a. Diaphoresis
   - b. Pallor
   - c. Cyanosis
   - d. Open wounds
   - e. Ecchymosis
   - f. Other evidence of trauma
6. Hemoptysis
7. Neck
   - a. Position of trachea
   - b. Subcutaneous emphysema
   - c. Jugular venous distention
   - d. Penetrating wounds
8. Chest
   - a. Contusions
   - b. Tenderness
   - c. Asymmetry
   - d. Lung sounds
     - (1) Absent or decreased
       - (a) Unilateral
       - (b) Bilateral
     - (2) Location
     - (3) Bowel sounds in hemithorax
   - e. Abnormal percussion finding
     - (1) Hyperresonance
     - (2) Hyporesonance
   - f. Heart sounds
     - (1) Muffled
     - (2) Distant
     - (3) Regurgitant murmur
   - g. Shift of apical impulse
   - h. Open wounds
   - i. Impaled object or penetration
   - j. Crepitation
   - k. Paradoxical movement of chest wall segment
9. Scaphoid abdomen
10. Decreased level of consciousness
11. ECG
    - a. ST - T wave elevation or depression

b. Conduction disturbances
c. Rhythm disturbances

12. History
    a. Dyspnea
    b. Chest pain
    c. Associated symptoms
        (1) Other areas of pain or discomfort
        (2) Symptoms prior to incident
    d. Past history of cardiorespiratory disease
    e. Use of restraint in motor vehicle crash

C. Management
1. Airway and ventilation
    a. Oxygen therapy
    b. Endotracheal intubation
    c. Needle cricothyrotomy
    d. Surgical cricothyrotomy
    e. Positive pressure ventilation
    f. Occlude open wounds
    g. Stabilize chest wall
2. Circulation
    a. Manage cardiac dysrhythmias
    b. Intravenous access
3. Pharmacologic
    a. Analgesics
    b. Antiarrhythmics
4. Non-pharmacologic
    a. Needle thoracostomy
    b. Tube thoracostomy - in hospital management
    c. Pericardiocentesis - in hospital management
5. Transport considerations
    a. Appropriate mode
    b. Appropriate facility

III. Chest wall injuries
A. Rib fractures
1. Epidemiology
    a. Incidence
        (1) Infrequent until adult life
        (2) Most often elderly patients
        (3) Significant force required
    b. Morbidity/ mortality
        (1) Can lead to serious consequences
        (2) Older ribs more brittle and rigid
        (3) Associated underlying pulmonary or cardiovascular injury
        (4) Increases with
            (a) Age
            (b) Number of fractures
            (c) Location of fractures

2. Anatomy and physiology review
3. Pathophysiology
    a. Most often caused by blunt trauma, bowing effect with midshaft fracture
    b. Ribs 4 to 9 are most often fractured (thin and poorly protected)
    c. Respiratory restriction due to pain and splinting
        (1) Atelectasis
        (2) Ventilation/ perfusion mismatch
    d. May be associated with underlying lung or cardiac contusion
    e. Intercostal vessel injury
    f. Associated complications
        (1) First and second ribs are injured by severe trauma
            (a) Rupture of aorta
            (b) Tracheobronchial tree injury
            (c) Vascular injury
        (2) Left lower rib injury associated with splenic rupture
        (3) Right lower rib injury associated with hepatic injury
        (4) Multiple rib fractures
            (a) Atelectasis
            (b) Hypoventilation
            (c) Inadequate cough
            (d) Pneumonia
        (5) Open rib fracture associated with visceral injury
        (6) Posterior rib fracture
            (a) Fifth through ninth ribs most frequently injured
            (b) Lower ribs associated with spleen and kidney injury
4. Assessment findings
    a. Localized pain
    b. Pain that worsens
        (1) Movement
        (2) Deep breathing
        (3) Coughing
    c. Point tenderness
    d. Crepitus or audible crunch
    e. Splinting on respiration
    f. Anteroposterior pressure elicits pain
5. Management
    a. Airway and ventilation
        (1) Oxygen therapy
        (2) Positive pressure ventilation
        (3) Encourage coughing and deep breathing
    b. Pharmacological
        (1) Analgesics
    c. Non-pharmacological
        (1) Splint - but avoid circumferential splinting
    d. Transport consideration
        (1) Appropriate mode
        (2) Appropriate facility
    e. Psychological support/ communication strategies

B. Flail segment
   1. Epidemiology
      a. Incidence
         (1) Most common cause is vehicular crash
         (2) Falls from heights
         (3) Industrial accidents
         (4) Assault
         (5) Birth trauma
      b. Morbidity/ mortality
         (1) Significant chest trauma
         (2) Mortality rates 20-40% due to associated injuries
         (3) Mortality increased with
            (a) Advanced age
            (b) Seven or more rib fractures
            (c) Three or more associated injuries
            (d) Shock
            (e) Head injuries
   2. Pathophysiology
      a. Three or more ribs fractured in two or more places producing a free floating segment of chest wall
      b. Respiratory failure due to
         (1) Underlying pulmonary contusion
         (2) Associated intrathoracic injury
         (3) Inadequate bellow action of chest
      c. Paradoxical movement of the chest
         (1) Minimal because of muscle spasm
         (2) Must be large to compromise ventilation
      d. Pain
         (1) Reduces thoracic expansion
         (2) Decreases ventilation
      e. Pulmonary contusion
         (1) Decreased lung compliance
         (2) Intra alveolar-capillary hemorrhage
         (3) Alveolar hemorrhage
      f. Decreased ventilation
      g. Impaired venous return with resultant ventilation-perfusion mismatch
      h. Hypercapnia
      i. Hypoxia
   3. Assessment findings
      a. Chest wall contusion
      b. Respiratory distress
      c. Paradoxical chest wall movement
      d. Pleuritic chest pain
      e. Crepitus
      f. Pain and splinting of affected side
      g. Tachypnea
      h. Tachycardia
      i. Possible bundle branch block on ECG

4. Management
    a. Airway and ventilation
        (1) Positive pressure ventilation may be needed
        (2) Oxygen (high concentration)
        (3) Evaluate the need for endotracheal intubation
        (4) Stabilize flail segment (may be controversial locally)
        (5) Positive end expiratory pressure (PEEP)
    b. Circulation
        (1) Restrict fluids
    c. Pharmacologic
        (1) Analgesics
    d. Non-pharmacologic
        (1) Positioning
        (2) Endotracheal intubation and positive pressure ventilation for internal splinting effect
    e. Transport considerations
        (1) Appropriate mode
        (2) Appropriate facility
    f. Psychological support/ communication strategies

C. Sternal fracture
1. Epidemiology
    a. Incidence
        (1) 5-8% in blunt chest trauma
        (2) Deceleration compression injury
            (a) Steering wheel
            (b) Dashboard
        (3) Blow to chest
        (4) Severe hyperflexion of thoracic cage
        (5) Occur at or below the manubriosternal junction
    b. Morbidity/ mortality
        (1) 25-45% mortality
        (2) High association with myocardial or lung injury
            (a) Myocardial contusion
            (b) Myocardial rupture
            (c) Pulmonary contusion
2. Pathophysiology
    a. Associated injuries cause morbidity and mortality
        (1) Pulmonary and myocardial contusion
        (2) Flail chest
        (3) Vascular disruption of thoracic vessels
        (4) Intraabdominal injuries
        (5) Head injuries
    b. Rarely is fracture displaced posteriorly to directly impinge on heart or vessels
3. Assessment findings
    a. Localized pain
    b. Tenderness over sternum
    c. Crepitus
    d. Tachypnea

e. ECG changes associated with myocardial contusion
f. History of blunt trauma

4. Management
   a. Airway and ventilation
   b. Circulation
      (1) Restrict fluids if pulmonary contusion is suspected
5. Pharmacologic
   a. Analgesics
6. Non-pharmacologic
   a. Allow chest wall self-splinting
7. Transport considerations
   a. Appropriate mode
   b. Appropriate facility
8. Psychological support/ communication strategies

IV. Injury to the lung

A. Simple pneumothorax

1. Epidemiology
   a. Incidence
      (1) 10-30% in blunt chest trauma
      (2) Almost 100% with penetrating chest trauma
   b. Morbidity/ mortality
      (1) Extent of atelectasis
      (2) Associated injuries
2. Pathophysiology
   a. Lung 1-3 cm away from the chest wall
   b. May have stable amount of accumulation of air
   c. Pulmonary function may be good
   d. Internal wound allows air to enter the pleural space
   e. Small tears self-seal, larger one may progress
   f. Paper bag syndrome
   g. If standing air will accumulate in the apices, check there first for diminished breath sounds otherwise, if supine it accumulates in the anterior chest
   h. Trachea may tug towards the effected side
   i. Ventilation/ perfusion mismatch
3. Assessment findings
   a. Tachypnea
   b. Tachycardia
   c. Respiratory distress
   d. Absent or decreased breath sounds on affected side
   e. Hyperresonance
   f. Decreased chest wall movement
   g. Dyspnea
   h. Chest pain referred to shoulder or arm on affected side
   i. Slight pleuritic chest pain
4. Management
   a. Airway and ventilation
      (1) Positive pressure ventilation if necessary

(2) Monitor for development of tension pneumothorax
b. Non-pharmacologic
(1) Needle thorocostomy
c. Transport consideration
(1) Appropriate mode
(2) Appropriate facility
5. Psychological support/ communication strategies

B. Open pneumothorax
1. Epidemiology
a. Incidence
(1) Penetrating trauma
b. Morbidity/ mortality
(1) Profound hypoventilation could result
(2) Death related to delayed management
2. Pathophysiology
a. Open defect in the chest wall
(1) Allows communication between pleural space and atmosphere
(2) Prevents development of negative intrapleural pressure
(3) Produces collapse of ipsilateral lung
(4) Inability to ventilate affected lung
(5) Ventilation/ perfusion mismatch
(a) Shunting
(b) Hypoventilation
(c) Hypoxia
(d) Large functional dead space
b. Air will enter pleural space during inspiratory phase
c. Air may exit during exhalation phase
d. Resistance to air flow through respiratory tract may be greater than through open wound resulting in ineffective respiratory effort
e. One way flap valve may let air in but not out resulting in built up pressure in pleural space
f. Direct lung injury may be present
g. Vena cava kinked from swaying of mediastinum
h. Preload decreased from knifing of inferior vena cava
3. Assessment findings
a. To and fro air motion out of defect
b. Defect in the chest wall
c. Penetrating injury to the chest which does not seal itself
d. Sucking sound on inhalation
e. Tachycardia
f. Tachypnea
g. Respiratory distress
h. Subcutaneous emphysema
i. Decreases breath sounds on affected side
4. Management
a. Airway and ventilation
(1) Positive pressure ventilation if necessary
(2) Monitor for development of tension pneumothorax

b. Non-pharmacologic
(1) Occlude open wound
(2) Tube thoracostomy - in hospital management
c. Transport consideration
(1) Appropriate mode
(2) Appropriate facility

5. Psychological support/ communication strategies

C. Tension pneumothorax

1. Epidemiology
a. Incidence
(1) Penetrating trauma
(2) Blunt trauma
b. Morbidity/ mortality
(1) Profound hypoventilation could result
(2) Death related to delayed management
(3) Immediate life-threatening chest injury

2. Pathophysiology
a. Defect in airway allowing communication with pleural space
b. Blunt trauma
(1) Penetration by rib fracture
(2) Sudden increase in intrapulmonary pressure
(3) Bronchial disruption from shear forces
c. Air trapped in pleural space with build up of pressure
d. Lung collapse on affected side with mediastinal shift to contralateral side
e. Lung collapse leads to right-to-left intrapulmonary shunting and hypoxia
f. Reduction in cardiac output
(1) Increased intrathoracic pressure
(2) Deformation of vena cava reducing preload (decreased venous return to heart)

3. Assessment findings
a. Unilateral decreased or absent breath sounds
b. Dyspnea
c. Tachypnea
d. Respiratory distress
e. Extreme anxiety
f. Cyanosis
g. Bulging of intercostal muscles
h. Tachycardia
i. Hypotension
j. Narrow pulse pressure
k. Subcutaneous emphysema
l. Jugular venous distention
m. Tracheal deviation
n. Hyperresonance

4. Management
a. Airway and ventilation
(1) Positive pressure ventilation if necessary
b. Circulation

(1) Relieve tension pneumothorax to improve cardiac output
c. Non-pharmacologic
(1) Occlude open wound
(2) Needle thoracentesis
(a) Equipment
(b) Technique
(c) Assess the need for a second or third needle insertion
(3) Tube thoracostomy - in hospital management
d. Transport consideration
(1) Appropriate mode
(2) Appropriate facility
e. Psychological support/ communication strategies

D. Hemothorax
1. Epidemiology
a. Incidence
(1) Associated with pneumothorax
(2) Blunt or penetrating trauma
(3) Rib fractures are frequent cause
b. Morbidity/ mortality
(1) Life-threatening injury that frequently requires urgent chest tube and/ or surgery
(2) Hemothorax associated with great vessel or cardiac injury
(a) 50% will die immediately
(b) 25% live five to ten minutes
(c) 25% may live 30 minutes or longer
2. Pathophysiology
a. Accumulation of blood in the pleural space
b. Bleeding from
(1) Penetrating or blunt lung injury
(2) Chest wall vessels
(3) Intercostal vessels
(4) Myocardium
c. Pulmonary parenchyma is low-pressure vascular system
d. Bleeding from pulmonary contusion generally causes 1000 to 1500 cc blood loss
e. Massive hemothorax indicates great vessel or cardiac injury
f. Collapse of ipsilateral lung
g. Respiratory insufficiency dependent on amount of blood
h. Hypoxia
i. Hypotension and inadequate perfusion may result from blood loss
j. Chest cavity can hold 2,000 to 3,000 ml of blood
k. Classified by amount of blood loss
l. Tissue pressure effects of legs, arms and abdomen versus thorax
(1) La Place law
(2) Extraluminal pressure in legs
(3) Extraluminal pressure in thorax
m. An intercostal artery can easily bleed 50 ccs per minute
n. Intrapulmonary hemorrhage
(1) Bronchus

(2) Parenchyma
3. Assessment findings
a. Tachypnea
b. Tachycardia
c. Dyspnea
d. Respiratory distress
e. Hypotension
f. Narrow pulse pressure
g. Pleuritic chest pain
h. Pale, cool, moist skin
i. Dullness on percussion
j. Decreased breath sounds
4. Management
a. Airway and ventilation
(1) Positive pressure ventilation if necessary
b. Circulation
(1) Re-expand the affected lung to reduce bleeding
c. Non-pharmacological
(1) Needle chest decompression
(2) Tube thoracostomy - in hospital management
d. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
e. Psychological support/ communication strategies

E. Hemopneumothorax
1. Pathophysiology
a. Pneumothorax with bleeding in pleural space
2. Assessment
a. Findings and management same as hemothorax
3. Management
a. Management is the same as a hemothorax

F. Pulmonary contusion
1. Epidemiology
a. Incidence
(1) Blunt trauma to chest
(a) Most common injury from blunt thoracic trauma
(b) 30-75% with blunt trauma have pulmonary contusion
(2) Associated commonly with rib fracture
(3) High energy shock waves from explosion
(4) High velocity missile wounds
(5) Rapid deceleration
(6) High incidence of extrathoracic injuries
(7) Low velocity - ice pick
b. Morbidity/ mortality
(1) Missed due to high incidence of other associated injuries
(2) Mortality between 14-20%
2. Pathophysiology
a. Three physical mechanisms

(1) Implosion effect
(a) Overexpansion of air in lungs secondary to positive-pressure concussive wave
(b) Rapid excessive stretching and tearing of alveoli
(2) Inertial effect
(a) Strips alveoli from heavier bronchial structures when accelerated at varying rates by concussive wave
(3) Spalding effect
(a) Liquid-gas interface is disrupted by shock-wave
(b) Wave releases energy
(c) Differential transmission of energy causes disruption of tissue

b. Alveolar and capillary damage with interstitial and intraalveolar extravasation of blood
c. Interstitial edema
d. Increased capillary membrane permeability
e. Gas exchange disturbances
f. Hypoxemia and carbon dioxide retention
g. Hypoxia causes reflex thickening of mucous secretions
(1) Bronchiolar obstruction
(2) Atelectasis
h. Blood is shunted away from unventilated alveoli leading to further hypoxemia

3. Assessment findings
a. Tachypnea
b. Tachycardia
c. Cough
d. Hemoptysis
e. Apprehension
f. Respiratory distress
g. Dyspnea
h. Evidence of blunt chest trauma
i. Cyanosis

4. Management
a. Airway and ventilation
(1) Positive pressure ventilation if necessary
b. Circulation
(1) Restrict intravenous fluids (use caution restricting fluids in hypovolemic patients)
c. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
d. Psychological support/ communication strategies

V. Myocardial injuries
A. Pericardial tamponade
1. Epidemiology
a. Incidence
(1) Rare in blunt trauma
(2) Penetrating trauma

(3) Occurs in less than 2% of chest trauma
b. Morbidity/ mortality
(1) Gunshot wounds carry higher mortality than stab wounds
(2) Lower mortality rate if isolated tamponade is present
2. Anatomy and physiology
a. Pericardium
(1) Tough fibrous sac
(2) Encloses heart
(3) Attaches to great vessels at the base of heart
(4) Two layers
(a) Visceral forms epicardium
(b) Parietal regarded as sac itself
(5) Purposes
(a) Anchor heart
(b) Restricts excess movement
(c) Prevents kinking of great vessels
(6) Parietal layer is acutely nondispensable but can chronically distend by as much as 1,000 to 1,500 ml
(7) Space between visceral and parietal layer is "potential space"
(8) Space normally filled with 30-50 ml of straw-colored fluid secreted by visceral layer
(a) Lubrication
(b) Lymphatic drainage
(c) Immunologic protection for heart
3. Pathophysiology
a. Rapid accumulation of fluid over a period of minutes to hours leads to increases in intrapericardial pressure
b. Increased intrapericardial pressure
(1) Compresses heart and decreases cardiac output due to restricted diastolic expansion and filling
(2) Hampers venous return
c. Myocardial perfusion decreases due to pressure effects on walls of heart and decreased diastolic pressures
d. Ischemic dysfunction may result in infarction
e. Removal of as little as 20 ml of blood may drastically improve cardiac output
4. Assessment findings
a. Tachycardia
b. Respiratory distress
c. Narrow pulse pressure
d. Pulsus paradoxus
e. Cyanosis
(1) Head
(2) Neck
(3) Upper extremities
f. Beck’s triad - advanced stage seen in only 30% of patients
(1) Hypotension
(2) Neck vein distention
(3) Muffled heart tones

g. Kussmaul's sign
h. ECG changes

5. Management
   a. Airway and ventilation
   b. Circulation
      (1) Fluid challenge
   c. Non-pharmacological
      (1) Pericardiocentesis - in hospital management
   d. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   e. Psychological support/ communication strategies

B. Myocardial contusion (blunt myocardial injury)

1. Epidemiology
   a. Incidence
      (1) 16-76% of blunt trauma
   b. Morbidity/ mortality
      (1) Significant cause of morbidity and mortality in the blunt trauma patient

2. Pathophysiology
   a. Hemorrhage with edema and fragmented myocardial fibers
   b. Cellular injury
   c. Vascular damage may occur
   d. Hemopericardium may occur from lacerated epicardium or endocardium
   e. Fibrinous reaction at contusion site may lead to
      (1) Delayed rupture
      (2) Ventricular aneurysm
   f. Areas of damage are well demarcated
   g. Conduction defects

3. Assessment findings
   a. Associated injuries
      (1) One to three rib fractures
      (2) Sternal fracture
   b. Retrosternal chest pain
   c. ECG changes
      (1) Persistent tachycardia
      (2) ST elevation, T wave inversion
      (3) Right bundle branch block
      (4) Atrial flutter, fibrillation
      (5) Premature ventricular contractions
      (6) Premature atrial contractions
   d. New cardiac murmur
   e. Pericardial friction rub (late)

4. Management
   a. Airway and ventilation
      (1) Oxygen therapy
   b. Circulation
      (1) Intravenous fluid volume
   c. Pharmacological

(1) Antiarrhythmics
(2) Vasopressors
d. Transport considerations
(1) Appropriate mode
(2) Appropriate facility
e. Psychological support/ communication strategies

C. Myocardial rupture
1. Associated with immediate trauma or delayed for 2-3 weeks
2. Associates with blunt trauma
a. Compression between sternum and vertebrae
3. Penetrating trauma
a. Rib
b. Missile
c. Sternal bone
4. History of trauma with a presentation of
a. Congestive heart failure
b. Cardiac tamponade
5. Immediate onset of congestive heart failure following trauma
a. Rupture of cardiac valves
b. Intraventricular septal rupture
6. Management is supportive

VI. Vascular injuries
A. Aortic dissection/ rupture
1. Epidemiology
a. Incidence
(1) Blunt trauma
(a) Motor vehicle crash
(b) Falls
(2) 15% of all blunt trauma deaths
2. Morbidity/ mortality
a. 85-95% die instantaneously
b. 10-15% survive to arrive at hospital
(1) 33% of survivors die within six hours
(2) 33% of survivors die within twenty-four hours
(3) 33% survive three days or longer
3. Pathophysiology
a. Shear injury
b. Separation of the aortic intima and media
c. Blood enters media through a small intima tear
d. Tear due to effect of high speed deceleration on portions of the aorta at points of relative fixation
e. Increased intraluminal pressure results from impact
f. Thinned out layer may rupture
g. Descending aorta at the isthmus just distal to left subclavian artery is most common site of rupture (ligamentum arteriosom)
h. Ruptures of ascending aorta much less common
4. Assessment findings
a. Retrosternal or interscapular pain

b. Dyspnea
c. Dysphagia
d. Ischemic pain of the extremities
e. Upper extremity hypertension with absent or decreased amplitude of femoral pulses
f. Harsh systolic murmur over precordium or interscapular region

5. Management
   a. Airway and ventilation
   b. Circulation
      (1) Do not over hydrate
   c. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility
   d. Psychological support/ communication strategies

B. Penetrating wounds of the great vessels
1. Usually involve
   a. Chest
   b. Abdomen
   c. Neck
2. Wounds are accompanied by
   a. Massive hemothorax
   b. Hypovolemic shock
   c. Cardiac tamponade
   d. Enlarging hematomas
3. Hematomas may cause compression of any structure
   a. Vena cava
   b. Trachea
   c. Esophagus
   d. Great vessels
   e. Heart
4. Management
   a. Manage hypovolemia
      (1) PASG not recommended
   b. Relief of tamponade if present
   c. Expeditious transport

VII. Other thorax injuries
A. Diaphragmatic injury
1. Epidemiology
   a. Incidence
      (1) Blunt trauma
      (2) Penetrating trauma
      (3) Frequently encountered injury
   b. Morbidity/ mortality
      (1) Could be life-threatening
2. Pathophysiology
   a. High-pressure compression to abdomen with resultant intra-abdominal pressure increase

b. Can produce very subtle signs and symptoms
c. Bowel obstruction and strangulation
d. Restriction of lung expansion
(1) Hypoventilation
(2) Hypoxia
e. Mediastinal shift
(1) Cardiac compromise
(2) Respiratory compromise

3. Assessment findings
a. Tachypnea
b. Tachycardia
c. Respiratory distress
d. Dullness to percussion
e. Scaphoid abdomen
f. Bowel sounds in affected hemithorax
g. Decreased breath sounds

4. Management
a. Airway and ventilation
(1) Positive pressure ventilation if necessary
(2) Caution IPPB may worsen the injury
b. Non-pharmacologic
(1) Do not place patient in Trendelenburg position
c. Transport consideration
(1) Appropriate mode
(2) Appropriate facility
d. Psychological support/ communication strategies

B. Esophageal injury

1. Epidemiology
a. Incidence
(1) Penetrating trauma most frequent cause
(2) Rare in blunt trauma
b. Morbidity/ mortality
(1) Could be life-threatening if missed

2. Pathophysiology
a. Missile and knife wounds penetrate esophagus
b. Can perforate spontaneously
(1) Violent emesis
(2) Carcinoma
(3) Anatomic distortions produced by diverticulae or gastric reflux

3. Assessment findings
a. Pain
b. Fever
c. Hoarseness
d. Dysphagia
e. Respiratory distress
f. Cervical esophageal perforation
(1) Local tenderness
(2) Subcutaneous emphysema

(3) Resistance of neck on passive motion
g. Intrathoracic esophageal perforation
(1) Mediastinal emphysema
(2) Mediastinitis
(3) Subcutaneous emphysema
(4) Mediastinal crunch
(5) Splinting of chest wall
h. Respiratory distress
i. Shock
4. Management
a. Airway and ventilation
b. Transport consideration
(1) Appropriate mode
(2) Appropriate facility
c. Psychological support/ communication strategies

C. Tracheo-bronchial injuries
1. Epidemiology
a. Incidence
(1) Rare injury - less than 3% of chest trauma
(2) Penetrating trauma
(3) Blunt trauma
b. Morbidity/ mortality
(1) High mortality rate - greater than 30%
2. Pathophysiology
a. Majority occur within 3 cm of carina
b. Tear can occur anywhere along tracheal/ bronchial tree
c. Rapid movement of air into pleural space
d. Tension pneumothorax refractory to needle decompression
e. Continuous flow of air from needle of decompressed chest
f. Severe hypoxia
3. Assessment
a. Tachypnea
b. Tachycardia
c. Massive subcutaneous emphysema
d. Dyspnea
e. Respiratory distress
f. Hemoptysis
g. Signs of tension pneumothorax that doesn't respond to needle decompression
4. Management
a. Airway and ventilation
b. Circulation
c. Transport consideration
(1) Appropriate mode
(2) Appropriate facility

D. Traumatic asphyxia
1. Epidemiology
a. Incidence
b. Morbidity/ mortality

2. Pathophysiology
   a. Sudden compressional force squeezes the chest
   b. Blood backs up into the head and neck
   c. Jugular veins engorge, capillaries rupture
3. Assessment
   a. Cyanosis to the face and upper neck
   b. Jugular venous distention
   c. Swelling or hemorrhage of the conjunctiva
   d. Skin below area remains pink
   e. Hypotension when pressure released
4. Management
   a. Airway and ventilation
   b. Circulation
      (1) Expect hypotension once compression is released
   c. Pharmacological
      (1) Sodium bicarbonate should be guided by ABGs in hospital
   d. Transport considerations
      (1) Appropriate mode
      (2) Appropriate facility

VIII. Integration

UNIT TERMINAL OBJECTIVE

4-8 At the completion of this unit, the paramedic student will be able to integrate pathophysiologic principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with suspected abdominal trauma.

COGNITIVE OBJECTIVES

At the completion of this unit, the paramedic student will be able to:

4-8.1 Describe the epidemiology, including the morbidity/mortality and prevention strategies for a patient with abdominal trauma. (C-1)
4-8.2 Describe the anatomy and physiology of organs and structures related to abdominal injuries. (C-1)
4-8.3 Predict abdominal injuries based on blunt and penetrating mechanisms of injury. (C-2)
4-8.4 Describe open and closed abdominal injuries. (C-1)
4-8.5 Explain the pathophysiology of abdominal injuries. (C-1)
4-8.6 Describe the assessment findings associated with abdominal injuries. (C-1)
4-8.7 Identify the need for rapid intervention and transport of the patient with abdominal injuries based on assessment findings. (C-1)
4-8.8 Describe the management of abdominal injuries. (C-1)
4-8.9 Integrate the pathophysiological principles to the assessment of a patient with abdominal injury. (C-3)
4-8.10 Differentiate between abdominal injuries based on the assessment and history. (C-3)
4-8.11 Formulate a field impression for patients with abdominal trauma based on the assessment findings. (C-3)
4-8.12 Develop a patient management plan for patients with abdominal trauma based on the field impression. (C-3)
4-8.13 Describe the epidemiology, including the morbidity/ mortality and prevention strategies for solid organ injuries. (C-1)
4-8.14 Explain the pathophysiology of solid organ injuries. (C-1)
4-8.15 Describe the assessment findings associated with solid organ injuries. (C-1)
4-8.16 Describe the treatment plan and management of solid organ injuries. (C-1)
4-8.17 Describe the epidemiology, including the morbidity/ mortality and prevention strategies for hollow organ injuries. (C-1)
4-8.18 Explain the pathophysiology of hollow organ injuries. (C-1)
4-8.19 Describe the assessment findings associated with hollow organ injuries. (C-1)
4-8.20 Describe the treatment plan and management of hollow organ injuries. (C-1)
4-8.21 Describe the epidemiology, including the morbidity/ mortality and prevention strategies for abdominal vascular injuries. (C-1)
4-8.22 Explain the pathophysiology of abdominal vascular injuries. (C-1)
4-8.23 Describe the assessment findings associated with abdominal vascular injuries. (C-1)
4-8.24 Describe the treatment plan and management of abdominal vascular injuries. (C-1)
4-8.25 Describe the epidemiology, including the morbidity/ mortality and prevention strategies for pelvic fractures. (C-1)
4-8.26 Explain the pathophysiology of pelvic fractures. (C-1)
4-8.27 Describe the assessment findings associated with pelvic fractures. (C-1)
4-8.28 Describe the treatment plan and management of pelvic fractures. (C-1)
4-8.29 Describe the epidemiology, including the morbidity/ mortality and prevention strategies for other related abdominal injuries. (C-1)
4-8.30 Explain the pathophysiology of other related abdominal injuries. (C-1)
4-8.31 Describe the assessment findings associated with other related abdominal injuries. (C-1)
4-8.32 Describe the treatment plan and management of other related abdominal injuries. (C-1)
4-8.33 Apply the epidemiologic principles to develop prevention strategies for abdominal injuries. (C-2)

4-8.34 Integrate the pathophysiological principles to the assessment of a patient with abdominal injuries. (C-3)
4-8.35 Differentiate between abdominal injuries based on the assessment and history. (C-3)
4-8.36 Formulate a field impression based upon the assessment findings for a patient with abdominal injuries. (C-3)
4-8.37 Develop a patient management plan for a patient with abdominal injuries, based upon field impression. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-8.38 Advocate the use of a thorough assessment to determine a differential diagnosis and treatment plan for abdominal trauma. (A-3)
4-8.39 Advocate the use of a thorough scene survey to determine the forces involved in abdominal trauma. (A-3)
4-8.40 Value the implications of failing to properly diagnose abdominal trauma and initiate timely interventions to patients with abdominal trauma. (A-2)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-8.41 Demonstrate a clinical assessment to determine the proper treatment plan for a patient with suspected abdominal trauma. (P-1)
4-8.42 Demonstrate the proper use of PASG in a patient with suspected abdominal trauma. (P-1)
4-8.43 Demonstrate the proper use of PASG in a patient with suspected pelvic fracture. (P-1)

DECLARATIVE

I. Introduction
  A. Epidemiology
    1. Increased incidence of morbidity and mortality
      a. Due to delay to surgical intervention
      b. Death occurs as a result of increased hemorrhage due to delay
        (1) Solid organ injuries
        (2) Hollow organ injuries
        (3) Abdominal vascular injuries
        (4) Pelvic fractures
    2. Prevention strategies
  B. Anatomy review
    1. Boundaries of the abdomen
      a. Diaphragm
      b. Anterior abdominal wall
      c. Pelvic skeletal structures
      d. Vertebral column
      e. Muscles of the abdomen and flanks
    2. Surface anatomy of the abdomen
      a. Quadrants
        (1) Upper
          (a) Right
          (b) Left
        (2) Lower
          (a) Right
          (b) Left
      b. Xiphoid
      c. Symphysis pubis
      d. Umbilicus
    3. Intraperitoneal structures
      a. Liver
      b. Spleen
      c. Stomach
      d. Small bowel
      e. Colon
      f. Gallbladder
      g. Female reproductive organs
    4. Retroperitoneal structures
      a. Central structures
        (1) Duodenum
        (2) Pancreas
        (3) Major vascular structures
      b. Lateral structures
        (1) Kidneys
        (2) Ureters
        (3) Posterior ascending and descending colon
      c. Pelvic structures

(1) Rectum
(2) Ureters
(3) Pelvic vascular plexus
(4) Major vascular structures
(5) Pelvic skeletal structures
(6) Reproductive organs

5. Physiology review
   a. Injury to abdominal structures causes morbidity and mortality primarily as a result of hemorrhage
   b. Injury may be subtle
   c. High index of suspicion
   d. Solid organs
      (1) Hemorrhage
      (2) Shock
   e. Hollow organs
      (1) Spillage of contents
      (2) Peritonitis
   f. Vascular structures
      (1) Hemorrhage
      (2) Shock

C. Mechanism of injury review
   1. Index of suspicion
   2. Blunt mechanisms
      a. Compression forces
      b. Shear forces
      c. Deceleration forces
      d. Motor vehicle collisions
         (1) Head-on or frontal impact
            (a) Down and under path
            (b) Up and over path
         (2) Rear impact
         (3) Lateral or side impact
         (4) Rotational impact
         (5) Rollover
         (6) Restrained (type of restraint) or unrestrained
         (7) Seat belt injuries
         (8) Steering wheel injuries
      e. Motorcycle collisions
      f. Pedestrian injuries
      g. Falls
      h. Assault
      i. Blast injuries
   3. Penetrating mechanisms
      a. Energy imparted to the body
         (1) Low velocity
            (a) Knife
            (b) Ice pick
         (2) Medium velocity

(a) Gunshot wounds
(b) Shotgun wounds
(3) High velocity
(a) High power hunting rifles
(b) Military weapons
(c) Ballistics
(d) Trajectory
(e) Distance

II. General system pathophysiology, assessment, and management
A. Pathophysiology of abdominal injuries
1. Hemorrhage
a. No external signs
b. Rapid blood loss
c. Hypovolemic shock
d. Blood is not chemical irritant to peritoneum (therefore, no peritonitis)
2. Spillage of contents
a. Enzymes
b. Acids
c. Bacteria
d. Chemical irritation to peritoneum (peritonitis)
e. Localized pain sensation via somatic nerve fibers
f. Muscular spasm secondary to peritonitis (rigid abdomen)
B. Assessment
1. Focused history and physical examination
a. General
(1) Head injury and/ or intoxicants (drugs/ ethanol) mask signs and symptoms
(2) Hemoperitoneum (solid organ or vascular injuries)
(a) Blood not chemical irritant to peritoneum
(b) Adult abdomen will accommodate 1.5 liters with no abdominal distention
(c) Often present even with normal abdominal exam
(d) Unexplained shock
(e) Shock out of proportion to known injuries
(3) Peritonitis (hollow organ injury)
(a) Pain (subjective symptom from patient)
(b) Tenderness (objective sign with percussion/ palpation)
(c) Guarding/ rigidity
(d) Distention (late finding)
(4) Abrasions
(5) Ecchymosis
(6) Visible wounds
(7) Mechanism of injury
(8) Unexplained shock
b. Critical findings
(1) Rapid assessment and transport
(2) Detailed assessment
(3) On-going assessment

c. Noncritical findings
(1) Focused history and physical examination
(2) Other interventions and transport considerations

2. Comprehensive assessment
a. Vital signs
(1) Indications of shock
b. Inspection
(1) Abrasions
(2) Ecchymosis
(a) Seat belt sign
(3) Distention
(4) Obvious external blood loss
(5) Wounds
(6) Impaled object
(7) Evisceration
c. Auscultation - not useful out-of-hospital assessment tool
d. Percussion (tenderness)
e. Palpation
(1) Tenderness
(2) Guarding/ rigidity
(3) Pelvic stability/ tenderness
f. Absence of signs and/ or symptoms does not rule-out abdominal injuries
g. Not necessary to determine definitively if abdominal injuries are present
h. Examine the back

3. Differential diagnosis and continued management

C. Management/ treatment plan
1. Surgical intervention only effective therapy
2. No definitive therapy possible out-of-hospital
3. Rapid evaluation
4. Initiation of shock resuscitation
5. Rapid packaging and transport to nearest appropriate facility
a. Facility must have immediate surgical capability
b. Rapid transport
(1) Defeated if hospital cannot provide immediate surgical intervention
6. Crystalloid fluid replacement
a. En route to hospital
7. Airway support
8. Breathing support
9. Circulatory support
a. Control obvious hemorrhage
b. Tamponade bleeding
c. Manage hypotension
(1) Fluid resuscitation
10. Patient packaging
11. Transport
a. Indications for rapid transport
(1) Critical findings
(2) Surgical intervention required to control hemorrhage and/ or contamination

(3) High index of suspicion for abdominal injury
(4) Unexplained shock
(5) Physical signs of abdominal injury
(6) Hemorrhage continues until controlled in the operating room
(7) Survival determined by length of time from injury to definitive surgical control of hemorrhage
(8) Any delay in the field negatively impacts this time period

b. Indications for transport to trauma center
c. Indications for transport to acute care facility
d. Indications for no transport required

III. Specific injuries
A. Solid organ injuries
1. Epidemiology
a. Morbidity/ mortality
(1) Secondary to blood loss
(2) Result of blunt and penetrating injuries
b. Prevention strategies
c. Anatomy and physiology review
d. Pathophysiology
e. Assessment
(1) Initial assessment
(2) Focused history and physical examination
(a) Critical findings
i) Presence of shock
ii) Mechanism of injury
iii) Obvious external signs of abdominal trauma
iv) Unexplained shock
v) Shock out of proportion to known injuries
vi) Presence of physical signs of acute abdomen
a) Rigidity
b) Guarding
c) Distention
vii) Rapid assessment and transport
viii) Detailed assessment
ix) On-going assessment
(b) Non-critical findings
i) Focused history and physical examination
ii) Other interventions and transport considerations
iii) On-going assessment
(3) Comprehensive assessment
(a) Vital signs
(b) Inspection
(c) Percussion
(d) Palpation
(4) Differential diagnosis and continued management
f. Management/ treatment plan
(1) Airway support

(2) Breathing support
(3) Circulatory support
(4) Patient packaging
(5) Transport
(6) Psychological support/ communications strategies

2. Liver injuries
   a. Morbidity and mortality
      (1) Result of blood loss
   b. Injuries result of
      (1) Blunt trauma
      (2) Penetrating trauma
3. Splenic injuries
   a. Most frequently injured organ
      (1) Blunt trauma
      (2) Commonly associated with other intra abdominal injuries
      (3) May present with left shoulder pain
         (a) Result of diaphragm irritation
4. Kidney injuries
   a. Often presents with hematuria
   b. Back pain
5. Pancreas
   a. Most common with penetrating injuries
   b. May also occur as a result of pancreas being compressed against vertebral column by
      (1) Steering wheels
      (2) Handle bars
      (3) Other structures stronger then the pancreas
   c. Products of pancreas have an irritation effect on peritoneum
   d. Auto-digestion of tissue
6. Diaphragm
   a. Injury often insidious
   b. Herniation of abdominal contents into chest may occur

B. Hollow organ injuries
   1. Epidemiology
      a. Morbidity/ mortality
         (1) Secondary to blood loss and content spillage
         (2) Result of blunt and penetrating injuries
      b. Prevention strategies
      c. Anatomy and physiology review
      d. Pathophysiology
      e. Assessment
         (1) Initial assessment
         (2) Focused history and physical examination
            (a) Critical findings
               i) Presence of shock
               ii) Mechanism of injury
               iii) Obvious external signs of abdominal trauma
               iv) Unexplained shock

v) Shock out of proportion to known injuries
vi) Presence of physical signs of acute abdomen
a) Rigidity
b) Guarding
c) Distention
vii) Rapid assessment and transport
viii) Detailed assessment
ix) On-going assessment
(b) Non-critical findings
i) Focused history and physical examination
ii) Other interventions and transport considerations
iii) On-going assessment
(3) Comprehensive assessment
(a) Vital signs
(b) Inspection
(c) Percussion
(d) Palpation
(4) Differential diagnosis and continued management
f. Management/ treatment plan
(1) Airway support
(2) Breathing support
(3) Circulatory support
(4) Patient packaging
(5) Transport
(6) Psychological support/ communications strategies
2. Small and large intestines
a. Most often injured as a result of
(1) Penetrating injuries
b. Can occur with deceleration injuries
3. Stomach
a. Most often injured as a result of
(1) Blunt trauma
(2) Full stomach prior to incident increases risk of injury
4. Duodenum
a. Most often injured as a result of
(1) Blunt trauma
b. Recognition often delayed
5. Bladder
a. Most often injured as a result of
(1) Blunt trauma
(2) Full bladder prior to incident may increase risk of injury
b. Associated with pelvic injury
C. Abdominal vascular injuries
1. Epidemiology
a. Morbidity/ mortality
b. Prevention strategies
2. Anatomy and physiology review
3. Pathophysiology

4. Assessment
    a. Initial assessment
    b. Focused history and physical examination
        (1) Critical findings
            (a) Rapid assessment and transport
            (b) Detailed assessment
            (c) On-going assessment
        (2) Non-critical findings
            (a) Focused history and physical examination
            (b) Other interventions and transport considerations
            (c) On-going assessment
    c. Comprehensive assessment
        (1) Vital signs
        (2) Inspection
        (3) Percussion
        (4) Palpation
    d. Differential diagnosis and continued management
5. Management/ treatment plan
    a. Airway support
    b. Breathing support
    c. Circulatory support
    d. Patient packaging
    e. Transport
    f. Psychological support/ communications strategies

D. Pelvic fractures
1. Epidemiology
    a. Morbidity/ mortality
    b. Prevention strategies
2. Anatomy and physiology review
3. Pathophysiology
4. Assessment
    a. Initial assessment
    b. Focused history and physical examination
        (1) Critical findings
            (a) Rapid assessment and transport
            (b) Detailed assessment
            (c) On-going assessment
        (2) Non-critical findings
            (a) Focused history and physical examination
            (b) Other interventions and transport considerations
            (c) On-going assessment
        (3) Associated injuries
            (a) Bladder
            (b) Urethra
    c. Comprehensive assessment
        (1) Vital signs
        (2) Inspection
            (a) Check perineum for

i) Ecchymosis
ii) Blood
(b) Check meatus of penis for blood
(3) Palpation
d. Differential diagnosis and continued management
5. Management/ treatment plan
a. Airway support
b. Breathing support
c. Circulatory support
(1) PASG
d. Patient packaging
e. Transport
f. Psychological support/ communications strategies
E. Other related abdominal injuries
1. Abdominal wall injuries
a. Eviscerations
(1) Epidemiology
(a) Morbidity/ mortality
(b) Prevention strategies
(2) Anatomy and physiology review
(3) Pathophysiology
(4) Assessment
(a) Initial assessment
(b) Focused history and physical examination
i) Critical findings
a) Rapid assessment and transport
b) Detailed assessment
c) On-going assessment
ii) Non-critical findings
a) Focused history and physical examination
b) Other interventions and transport considerations
c) On-going assessment
(c) Comprehensive assessment
i) Vital signs
ii) Inspection
iii) Percussion
iv) Palpation
(d) Differential diagnosis and continued management
(5) Management/ treatment plan
(a) Airway support
(b) Breathing support
(c) Circulatory support
(d) Patient packaging
i) Do not replace organs back into abdomen
ii) Protect organs from further damage
iii) Cover with sterile saline moistened dressing
(e) Transport
(f) Psychological support/ communications strategies

UNIT TERMINAL OBJECTIVE

4-9 At the completion of this unit, the paramedic student will be able to integrate pathophysiological principles and the assessment findings to formulate a field impression and implement the treatment plan for the patient with a musculoskeletal injury.

COGNITIVE OBJECTIVE

At the completion of this unit, the paramedic student will be able to:

4-9.1 Describe the incidence, morbidity, and mortality of musculoskeletal injuries. (C-1)
4-9.2 Discuss the anatomy and physiology of the musculoskeletal system. (C-1)
4-9.3 Predict injuries based on the mechanism of injury, including: (C-3)
1. Direct
2. Indirect
3. Pathologic

4-9.4 Discuss the types of musculoskeletal injuries: (C-1)
a. Fracture (open and closed)
2. Dislocation/ fracture
3. Sprain
4. Strain

4-9.5 Discuss the pathophysiology of musculoskeletal injuries. (C-1)
4-9.6 Discuss the assessment findings associated with musculoskeletal injuries. (C-1)
4-9.7 List the six "P"s of musculoskeletal injury assessment. (C-1)
4-9.8 List the primary signs and symptoms of extremity trauma. (C-1)
4-9.9 List other signs and symptoms that can indicate less obvious extremity injury. (C-1)
4-9.10 Discuss the need for assessment of pulses, motor and sensation before and after splinting. (C-1)
4-9.11 Identify the need for rapid intervention and transport when dealing with musculoskeletal injuries. (C-1)
4-9.12 Discuss the management of musculoskeletal injuries. (C-1)
4-9.13 Discuss the general guidelines for splinting. (C-1)
4-9.14 Explain the benefits of cold application for musculoskeletal injury. (C-1)
4-9.15 Explain the benefits of heat application for musculoskeletal injury. (C-1)
4-9.16 Describe age associated changes in the bones. (C-1)
4-9.17 Discuss the pathophysiology of open and closed fractures. (C-1)
4-9.18 Discuss the relationship between volume of hemorrhage and open or closed fractures. (C-3)
4-9.19 Discuss the assessment findings associated with fractures. (C-1)
4-9.20 Discuss the management of fractures. (C-1)
4-9.21 Discuss the usefulness of the pneumatic anti-shock garment (PASG) in the management of fractures. (C-1)
4-9.22 Describe the special considerations involved in femur fracture management. (C-1)
4-9.23 Discuss the pathophysiology of dislocations. (C-1)
4-9.24 Discuss the assessment findings of dislocations. (C-1)
4-9.25 Discuss the out-of-hospital management of dislocation/ fractures, including splinting and realignment. (C-1)
4-9.26 Explain the importance of manipulating a knee dislocation/ fracture with an absent distal pulse. (C-1)
4-9.27 Describe the procedure for reduction of a shoulder, finger or ankle dislocation/ fracture. (C-1)

4-9.28 Discuss the pathophysiology of sprains. (C-1)
4-9.29 Discuss the assessment findings of sprains. (C-1)
4-9.30 Discuss the management of sprains. (C-1)
4-9.31 Discuss the pathophysiology of strains. (C-1)
4-9.32 Discuss the assessment findings of strains. (C-1)
4-9.33 Discuss the management of strains. (C-1)
4-9.34 Discuss the pathophysiology of a tendon injury. (C-1)
4-9.35 Discuss the assessment findings of tendon injury. (C-1)
4-9.36 Discuss the management of a tendon injury. (C-1)
4-9.37 Integrate the pathophysiological principles to the assessment of a patient with a musculoskeletal injury. (C-3)
4-9.38 Differentiate between musculoskeletal injuries based on the assessment findings and history. (C-3)
4-9.39 Formulate a field impression of a musculoskeletal injury based on the assessment findings. (C-3)
4-9.40 Develop a patient management plan for the musculoskeletal injury based on the field impression. (C-3)

AFFECTIVE OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-9.41 Advocate the use of a thorough assessment to determine a working diagnosis and treatment plan for musculoskeletal injuries. (A-3)
4-9.42 Advocate for the use of pain management in the treatment of musculoskeletal injuries. (A-3)

PSYCHOMOTOR OBJECTIVES
At the completion of this unit, the paramedic student will be able to:

4-9.43 Demonstrate a clinical assessment to determine the proper treatment plan for a patient with a suspected musculoskeletal injury. (P-1)
4-9.44 Demonstrate the proper use of fixation, soft and traction splints for a patient with a suspected fracture. (P-1)

DECLARATIVE

I. Introduction
  A. Epidemiology
    1. Incidence
      a. 70-80% of polytrauma patients suffer musculoskeletal injuries
      b. Blunt trauma
      c. Penetrating trauma
    2. Mortality/ morbidity
      a. Upper extremity injury
        (1) Contribute to long-term impairment
        (2) Rarely life-threatening
      b. Lower extremity injury
        (1) Associated with higher magnitudes of injury
        (2) More significant blood loss
        (3) More difficult to manage in polytrauma patient
        (4) Femur and pelvic injuries may constitute life threats
    3. Risk factors
    4. Prevention strategies
      a. Proper sports training
      b. Wearing seat belts
      c. Child safety seats
      d. Airbags
      e. Gun safety and education
      f. Motorcycle driver education
      g. Fall prevention
      h. Highrise window guards
      i. Other means of preventing musculoskeletal trauma
    5. Review of musculoskeletal anatomy
      a. Skin
        (1) Layer
        (2) Thickness
      b. Subcutaneous
        (1) Fat
        (2) Fascia
      c. General breakdown of the skeletal system
        (1) Axial skeleton
          (a) Forms the central (longitudinal) axis of the body, includes the following bones
            i) Skull
            ii) Vertebral column
            iii) Bony thorax
          (b) Appendicular skeleton
          (c) Pectoral girdle - bones that attach the upper limbs to the axial skeleton

i) Clavicle
ii) Scapula

(d) Pelvic girdle - consists of the paired bones of the pelvis that attach the lower limbs to the axial skeleton, and the sacrum

(2) Vessels
- (a) Arteries
  - i) Axillary
  - ii) Brachial
  - iii) Radial
  - iv) Ulnar
  - v) Hand arcade
  - vi) Digital
  - vii) Femoral
  - viii) Popliteal
  - ix) Dorsalis pedis
  - x) Posterior tibial
  - xi) Anterior tibial
  - xii) Foot arcade
  - xiii) Digital

(3) Muscles
- (a) Latissimus dorsae
- (b) Trapezius
- (c) Rhomboids
- (d) Deltoid
- (e) Triceps
- (f) Biceps
- (g) Forearm extensors
- (h) Intrinsic muscles of hand
- (i) Hamstring group
- (j) Quadriceps group
- (k) Adductor group
- (l) Gastrocenemius solius
- (m) Intraosseos

(4) Tendons
- (a) Extensors
- (b) Flexors

(5) Bones
- (a) Components of a longbone
  - i) Diaphysis
    - a) Long, narrow shaft
    - b) Very dense, compact bone
    - c) Yellow bone marrow that stores fat
  - ii) Periosteum
    - a) Outer covering for long bones
    - b) Vascular and full of nerves

c) Haversian canals allow circulation of blood
iii) Epiphysis
a) Articulated, widened end
b) Cancellous bone filled with red blood marrow
c) Responsible for growth in the infant and child
d) Weakest point in a child's bone and weaker than a child's ligaments
iv) Metaphysis
a) Area between the epiphysis and diaphysis

(6) Scapulae
(a) Upper division
(b) Lower division
(c) Glenoid fossa

(7) Clavicle
(a) Claviclulo-sternal joint
(b) Acromio-clavicular joint

(8) Humerus
(a) Head
i) Anatomical neck
ii) Surgical neck
(b) Tuberosities
(c) Shoulder joint
(d) Neck
(e) Shaft
(f) Medial condyle
(g) Lateral condyle
(h) Elbow

(9) Radius
(a) Elbow
(b) Head
(c) Shaft
(d) Wrist

(10) Ulna
(a) Elbow
(b) Olecranon
(c) Shaft
(d) Wrist

(11) Carpals
(a) Articulation
(b) Wrist
(c) Metacarpal joint

(12) Metacarpals
(a) Articulations
(b) Shaft

(13) Phalanges

(a) Metacarpal-phalange joint
(b) Proximal intraphalange joint
(c) Distal intraphalange joint

(14) Pelvis
(a) Ilium
(b) Ischium
(c) Pubis
(d) Acetabulum

(15) Femur
(a) Hip joint
(b) Head
(c) Neck
(d) Trochanters
i) Greater trochanter
ii) Lesser trochanter
(e) Shaft
(f) Medial and lateral condyles

(16) Tibia
(a) Knee joint
(b) Articular surfaces/ plateaus
(c) Shaft
(d) Medial malleolus

(17) Fibula
(a) Head
(b) Shaft
(c) Lateral malleolus

(18) Talus
(a) Ankle joint
(b) Articulation

(19) Calcaneus
(a) Heel
(b) Articulation

(20) Tarsals
(a) Articulations
(b) Arch

(21) Metatarsal
(a) Arch
(b) Articulations

(22) Phalanges
(a) Shaft
(b) Joints

d. Function
(1) Flexion
(2) Extension
(3) Rotation

e. Age associated changes in bones
   (1) Morphological changes
      (a) Water content of intervertebral disks decreases
      (b) Increased risk of disk herniation
      (c) Loss of ½ to 3/4 inch in stature is common
      (d) Bone tissue disorders shorten the trunk
      (e) Vertebral column gradually assumes an arc shape
      (f) Costal cartilages ossify making the thorax more rigid
      (g) Shallow breathing due to rigid thoracic cage
      (h) Facial contours change
   (2) Fractures
      (a) Bones are more prone to fracture since they are more porous and brittle
      (b) Vertebral and femoral neck fractures are most common
      (c) Degree of bone disorder (osteoporosis) is related to incidence of fracture

6. Physiology
   a. Purpose of the muscles
      (1) Cardiac muscle
         (a) Contracts rhythmically on its own
         (b) Generates electrical impulses
            i) Automaticity
            ii) Excitability
            iii) Conductivity
      (2) Smooth muscle
         (a) Found in lower airways, blood vessels, intestines
         (b) Under control of automatic nervous system
         (c) Can relax or contract to alter the inner lumen diameter
      (3) Skeletal muscle
         (a) Under conscious control
         (b) Major muscle mass of the body, allows mobility
   b. Muscular support of skeleton
      (1) Tendons
         (a) Bands of connective tissue binding muscles to bones (M-T-B)
         (b) Allows for power of movement across the joints
      (2) Cartilage
         (a) Connective tissue covering the epiphysis
         (b) Act as surface for articulation
         (c) Allow for smooth movement at joints
      (3) Ligaments
         (a) Connective tissue which support joints
         (b) Attach to bone ends
         (c) Allow for stable range of motion
   c. Purpose of the bones
      (1) Acts as a structural form, protects vital organs

(2) Acts as point of attachment for tendons, cartilage, and ligaments
(3) Structure for muscles to allow movement
(4) Stores salts and metabolic materials
(5) Produces red blood cells

d. Structural classifications of joints
(1) Fibrous
(a) Sutures - immovable
i) An immovable joint with one exception
ii) All bones of the skull are united by sutures
(b) Syndesmoses
(c) Gomphoses
(2) Cartilaginous
(a) Defined
(b) Synchondroses
(c) Symphysis
(3) Synovial
(a) Defined - fluid filled chamber which lubricates articulated surfaces
(b) Types of synovial joints
i) Plane
ii) Hinge
iii) Pivot
iv) Condyloid
v) Saddle
vi) Ball and socket

e. Movements allowed by synovial joints
(1) Gliding
(2) Angular movements
(a) Flexion
(b) Extension
(c) Abduction
(d) Adduction
(e) Circumduction
(3) Rotation

f. The interrelationship of the musculoskeletal system working together to move a complex joint (e.g., the knee)

II. Musculoskeletal pathophysiology-adult
A. Problems associated with musculoskeletal injuries
1. Hemorrhage
2. Instability
3. Loss of tissue
4. Simple lacerations and contamination
5. Interruption of blood supply
6. Long term disability

B. Fractures
  1. Types
    a. Open (compound)
    b. Closed (simple)
  2. Location
    a. Humerus
    b. Radius
      (1) Silver fork deformity
    c. Ulna
    d. Metacarpal
    e. Phalange
    f. Pelvis
      (1) Complications
        (a) Hemorrhage
        (b) Associated organs
        (c) Pregnancy complications
        (d) Associated dislocations
    g. Femur
      (1) Head
      (2) Neck
      (3) Intertrochanteric
      (4) Subtrochanteric
      (5) Shaft
      (6) Condylar
      (7) Supra condylar
    h. Tibia
      (1) Plateau
      (2) Shaft
      (3) Ankle
    i. Fibula
      (1) Shaft
      (2) Isolated
      (3) Ankle
    j. Ankle
      (1) Dislocation/ fracture
      (2) Malleal fracture
      (3) Tri malleolar
    k. Foot
      (1) Calcanei
      (2) March fracture
      (3) Meta tarsal dislocation
      (4) Phalanges
  3. X-ray descriptions of fractures
    a. Greenstick
    b. Oblique

c. Transverse
d. Comminuted
e. Spiral
f. Impacted
g. Epiphyseal fractures (in children)

C. Relate kinematics to the following injuries
1. Open fractures - break where protruding bone causes a soft tissue injury
a. Some bones are very close to the surface - reach down and touch your shin
b. EMS objective not to turn a closed fracture into an open fracture
2. Closed fractures - break in the bone which has not yet penetrated the soft tissue
a. May not be as obvious, yet serious potential for other injuries
3. Comminuted fractures - a break which involves several breaks in the bone causing bone fragment damage; consider the combined blood loss and potential for other injuries
4. Greenstick fractures - a bone break in which the bone is bent but only broken on the outside of the bend; children are most likely to have these
5. Spiral fracture - a bone break caused by a twisting motion
6. Oblique fracture - a bone break at a slanting angle across the bone
7. Transverse fracture - a broken bone that occurs at right angles to the long part of the bone involved
8. Dislocations - a bone moved from its normal position at a joint and may have associated fractures
9. Sprains - an injury to the tendons, muscles or ligaments around a joint, marked by pain, swelling, and dislocation of the skin over the joint
10. Strains - damage, usually muscular, that results from excessive physical effort
11. Joint injury - may be a fracture, dislocation or sprain
12. Stress fracture - a bone break, especially one or more of the foot bones, caused by repeated, long-term, or abnormal stress

D. Pathological fractures
E. Vascular injuries
F. Dislocations and subluxations
1. Subluxation
a. Partial dislocation of a joint with great damage and instability
2. Luxation
a. Complete dislocation of a joint
3. Dislocation
a. Frank displacement of bone ends at the joint
4. Specific injuries
a. Acromio clavicular
b. Shoulder
c. Elbow
d. Wrist
e. Metacarpal-phalange
f. Phalange
g. Hip
(1) Posterior

(2) Anterior
(3) Associated with fracture
h. Knee
(1) Posterior
(2) Anterior
(3) Patella
i. Ankle
(1) Posterior
(2) Fracture association
j. Foot
k. Hand

G. Lacerations
1. Protection
2. Hemostasis
3. Dressing

H. Hematoma

I. Sprains and strains
1. Sprain
a. Tearing of the ligaments surrounding a joint
b. Grades
(1) Grade I
(2) Grade II
(3) Grade III
(4) Repeated Grade I sprains can result in ligamentous stretching
(5) Grade III sprains can present the same as a fracture
2. Strain
a. Overstretching of a muscle or tendon
b. Examples

J. Typical blood loss in an uncomplicated fracture during the first two hours
1. Tibia/ fibula - 550 ml
2. Femur - 1000 ml
3. Pelvis - 2000 ml

K. Complications associated with fractures
1. Can exsanguinate from a fracture involving an artery laceration (e.g., femoral)
2. Major blood loss can occur at the beak point
3. Decreased distal pulse
4. Diminished distal sensory or motor function
5. Crushing injury
6. Amputation/ avulsion

L. Inflammatory and degenerative conditions
1. Bursitis and tendinitis
2. Arthritis
a. Osteoarthritis
b. Rheumatoid arthritis
c. Gouty arthritis

III. Musculoskeletal assessment
- A. Four classes of patients with musculoskeletal trauma
  1. Patients with life/ limb-threatening injuries or conditions, including life/ limb-threatening musculoskeletal trauma
  2. Patients with other life/ limb-threatening injuries and only simple musculoskeletal trauma
  3. Patients with life/ limb-threatening musculoskeletal trauma and no other life/ limb-threatening injuries
  4. Patients with only isolated, non-life/ limb-threatening injuries
- B. Conduct the initial survey first to determine if there are any life-threats
  1. Care for life-threatening conditions first
  2. Never overlook life/ limb-threatening musculoskeletal trauma
  3. Never allow a horrible looking, but noncritical musculoskeletal injury to distract you
- C. The six "p"s of musculoskeletal assessment
  1. Pain
     a. Pain on palpation (tenderness)
     b. Pain upon movement
  2. Pallor - pale skin or poor capillary refill
  3. Paresthesia - pins and needles sensation
  4. Pulses - diminished or absent
  5. Paralysis - inability to move
  6. Pressure
- D. Assessment of musculoskeletal injury
  1. General findings - inspect and palpate DCAP-BTLS
     a. Deformity
     b. Contusions
     c. Abrasions
     d. Penetrations or punctures
     e. Burns
     f. Tenderness
     g. Lacerations
     h. Swelling
  2. Specific findings - inspect and palpate
     a. Position found
     b. Hematoma
     c. Dislocation
     d. Cyanosis
     e. Motion - reduced or abnormally enlarged range
     f. Bleeding
     g. Guarding or self-splinting
     h. Crepitus
- E. Assessment findings - palpation
  1. Tenderness or pain
  2. Deformation
  3. Crepitation

4. Swelling/ skin tension
5. Pulses
6. Capillary refilling
7. Innervation

F. Special sports considerations
1. Mechanism of injury
   a. Football
   b. Basketball
   c. In-line skating
   d. Skiing or snow boarding
   e. Wrestling
   f. Soccer
   g. Rock climbing
2. Special sports injuries
   a. Shoulder
   b. Elbow
   c. Wrist
   d. Clavicle
   e. Knee
   f. Ankle
   g. Foot
   h. Tibia/ fibula
3. Interfacing with athletic trainers

IV. Management
A. General principles
1. Splint joint above and below as well as bone ends
2. Immobilize open and closed fracture the same
3. Cover open fracture to minimize contamination
4. Check pulses, sensation, and motor function before and after splinting
5. Stabilize with gentle in-line traction to position of normal alignment
6. Immobilize where they are found not in the exact position the limb is found
   a. It makes most sense to move a long bone injury into a “splintable” straight position
   b. Joint injuries are only moved if there is no distal pulse
7. Immobilize dislocation/ fractures in position of comfort and good vascular supply
8. Immobilize joints as found
9. Application of cold
   a. Reduce swelling
   b. Reduce pain
10. Compression
11. Elevation of extremities

B. Splints - rigid, formable, traction
1. Cardboard
2. Wood

3. Air
4. Traction
    a. History
    b. Principle
    c. Types
        (1) Unipolar
        (2) Bipolar
5. Vacuum
6. Pillow/ blanket
7. Short spinal immobilization devices
    a. Refer to spinal injury section
8. Long spinal immobilization devices
    a. Ultimate body splint
    b. Refer to spinal injury section

C. Dislocation/ fractures
1. Realignment
    a. Typically dislocated joints should be immobilized in the position of injury and transported for reduction
    b. Delayed or prolonged transport requires a different approach
    c. An attempt to reposition any dislocated joint into anatomical position should be made if distal circulation is impaired and if transportation is long or prolonged
    d. Check circulation and nerve function before and after any manipulation of any injured bone or joint
    e. Discontinue an attempt at repositioning if
        (1) Pain is increased significantly by manipulation, and/ or
        (2) Resistance to movement is encountered
2. Limb-threatening injuries
    a. Knee dislocation/ fracture
    b. Dislocation/ fracture of the ankle
    c. Subcondular fractures of the elbow
3. Always assess pulses, sensation, and motor function before and after manipulating the injury
4. Specific techniques for specific joints
    a. Finger realignment
    b. Hip realignment
        (1) One attempt if there is severe neurovascular compromise
        (2) As soon as possible after the injury
        (3) Do not attempt if associated with other severe injuries
        (4) Analgesics
        (5) Procedure
            (a) Traction
            (b) Hip 90 degrees
            (c) Knee 90 degrees
            (d) Along shaft of femur
            (e) Steady and slow to relax muscle spasm

(f) Success
i) "Pop" into joint
ii) Sudden relief of pain
iii) Leg can easily and painlessly be returned to full extension
(g) Immobilization, full extension, long backboard, reevaluation of pulses and innervation
(h) Immobilization, comfortable flexion not to exceed 90 degrees, pillows, chair, cardboard, supine position of patient

c. Knee realignment - do not confuse with a patella dislocation, this is a limb-threatening injury
(1) One attempt if there is severe neurovascular compromise
(2) As soon as possible after the injury
(3) An attempt to reposition a dislocation of the knee into anatomical position should be made if transport time is delayed or prolonged greater than two hours, even if distal circulation is normal
(4) Do not attempt if associated with other severe injuries
(5) Analgesics
(6) Procedure
(a) Apply gentle and steady traction and then move the injured joint into normal position
(b) Full extension
(c) Steady pull to relax muscle spasm
(d) Success
i) "Pop" into joint
ii) Loss of deformity
iii) Relief of pain
iv) Knee is now more mobile
(e) Immobilization, full extension, backboard, long board splints, no traction, assess pulses, position of greatest comfort, slight flexion

d. Ankle realignment
(1) One attempt if there is severe neurovascular compromise
(2) As soon as possible after the injury
(3) Do not attempt if associated with other severe injuries
(4) Analgesic
(5) Procedure
(a) Pull traction on the talus while stabilizing the tibia
(b) Slow and steady to relax spasm
(c) Success, sudden rotation to normal position
(d) Immobilization, as per fracture, check distal pulse

e. Shoulder realignment
(1) One attempt if there is severe neurovascular compromise
(2) As soon as possible after the injury
(3) Do not attempt if associated with other severe injuries or back injuries
(4) Analgesic

(5) Procedure
(a) Pull traction in the anatomical position only

D. Specific fracture pointers and immobilization techniques
1. Pelvis
a. Backboard and PASG
b. Treat the hypoperfusion as pelvic fractures cause severe hemorrhage, losing greater than 2 liters of blood into the pelvic cavity
2. Femur
a. Traction splinting procedure
(1) Direct manual stabilization of the injured leg
(2) Assess distal motor ability, sensory response, and circulation
(3) Rule out any contraindication to traction splinting
(4) Direct application of manual traction if elevating the leg from the ground
(5) Adjust and position splint at the injured leg
(6) Apply proximal securing device (e.g., ischial strap)
(7) Apply distal securing device (e.g., ankle hitch)
(8) Apply mechanical traction
(9) Position and secure support straps
(10) Re-evaluate the proximal/ distal circulation
(11) Reassess distal motor ability, sensory response, and circulation
(12) Secure patient's torso and traction splint to long backboard for transport
b. PASG and long backboard
c. Long backboard and long board splints
d. Opposite extremity and long backboard
e. Fractures of the proximal femur present similar to the anterior hip dislocation
f. Midshaft or distal femur fractures can have soft tissue, vascular and nerve damage
3. Tibia/ fibula
a. Pneumatic splint
b. Long board splint procedure
(1) Take body substance isolation
(2) Direct application of manual stabilization
(3) Assess distal motor ability, sensory response, and circulation
(4) Measure splint
(5) Apply splint
(6) Immobilize joints above and below the injury site
(7) Secure the entire injured extremity in a distal to proximal direction
(8) Immobilize hand/ foot in the position of function
(9) Reassess distal motor ability, sensory response, and circulation
c. Splinting to the opposite leg
d. Cardboard
4. Ankle - same as tibia/ fibula fractures, generally involves the distal tibia and fibula
a. Pillow splint and leg immobilization
b. Air splint
5. Foot

a. Pneumatic
b. Cardboard
c. Ladder splint

6. Shoulder dislocation/ fracture
   a. Anterior - arm close to the chest and hollow shoulder
   b. Posterior - arm may be over the head
   c. Splinting - be creative, improvise to hold the injury in place (e.g., blanket roll)
      (1) Use a rolled blanket with a cravat through the center
      (2) Position the roll under the elevated arm and secure it like a sling with the cravat through the blanket
      (3) Swathe the arm to prevent upward movement
      (4) If the arm is over the head - splint in position, or pull traction along the long axis of the arm
7. Knee
   a. High incidence of vascular and nerve damage
   b. Any fracture within three inches of a joint should be treated similar to a dislocation
   c. Use triangulation with cravats and two long padded splints
   d. SAM splints are not strong enough for the knee while some ladder splints if properly padded will be effective with immobilization of the hip and ankle
   e. Do not use a traction splint
   f. If found straight use two board splints or cardboard splint
8. Humerus
   a. Difficult to stabilize
   b. Potential for severe circulatory problems
   c. If the patient has a potential neck injury do not tie a sling around the neck
   d. Use a sling and swathe with splints surrounding the humerus or splint with the extremity extended
9. Elbow
   a. High probability for blood vessel and nerve damage
   b. Especially dangerous in children (supracondylar fractures)
   c. Volkman's contracture may result
   d. Padded wire splint and sling and swathe
10. Forearm fracture
    a. May involve radius, ulna, or both
    b. Colle's fracture of the wrist presents with the wrist in a "silver fork" position
    c. Splint like a lower leg fracture described above
11. Hand and wrist fractures
    a. Common with direct trauma
    b. Noticeable deformity
    c. Significant pain
    d. High incidence for nerve and vessel damage
    e. Splint on a padded board splint with the hand in position of function
12. Epiphyseal fractures
    a. Weakest part a child's joint
    b. Presents as a sprain in an adult

c. May result in a permanent angulation or deformed extremities
d. May cause premature arthritis

E. Application of cold/ heat
1. Cold in the first 48 hours to reduce swelling
2. Heat after 48 hour to increase circulation

F. Referral of minor musculoskeletal injuries
1. Evaluate the need for immobilization
2. Evaluate the need for an x-ray
3. Evaluate the need for a physician follow-up visit versus ED visit
4. Contact medical control for advisement

V. Integration